Arson by

Electronics

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INTRODUCTION:

The electronics industry in general has enjoyed a phenomenal growth within the past score of years, a growth that has continued on an accelerating scale especially during the preceeding decade. Expansion of the industry will certainly go on toward limitations that cannot be foreseen, as the art of electronics becomes incorporated more and more into our everyday scheme of living.

In the State of Florida, the development of such activities has been, and continues to be of great economic importance. Measured by employment alone, electronics in Florida increased by a factor of ten between the years 1953 and 1961. In fact, in 1961, the electronics firms in this state employed well over 12,000 persons. And these figures alone do not reflect the true increase in size of the industry itself and industries possessing a close relationship. Herein we refer to aircraft, missiles, scientific instruments and nucleonics.

Numerous groups are engaged in the production of electronic devices, and many others are producing electronic and other precision components for various Florida manufacturers. Research is being carried on by many of these companies, either as their sole activity, or as an additional activity. Electronic items now being produced in quantity in Florida include, but are not limited to, X-ray tubes, microwave and receiving tubes, printed circuits, transistors, coils, solenoids, resistors, capacitors, transformers, relays, regulators, timing devices, commutators, communications equipment, computers, and radar guidance and control systems.

The greatest concentration of these businesses may be found in the Miami area, orlando, Patrick Air Force Base, Port Canaveral, St. Petersburg, Clearwater, Tampa, West Palm Beach, Cocoa Beach, Eglin Air Force Base, and Fort Lauderdale, but smaller groups and individuals are scattered from one end of the state to the other.

From the standpoint of the economic welfare of Florida, all of the considerations are on the good side of the ledger, but at the same time, these facts pose a potential problem to the law enforcement agencies; a problem that is real and also rather frightening.

We are speaking, of course, of the possibility that the personnel and techniques now employed in these precision enterprises may become diverted into criminal paths. To be more specific, the Office of the State Fire Marshal is concerned with the diversion of these capabilities toward the crime of arson and the origination of explosions of a criminal nature. We are doubly at a disadvantage in the State of Florida, since there is great emphasis on research among our electronics people; that is to say, some of the country's best electronic brains are here. This points to the conceivability that we will not be dealing with criminals possessing limited skill, but rather with those of the highest ability. Sir Arthur Conan Doyle once stated that there is no criminal so dangerous as a doctor who has gone wrong, and should a well schooled electronics employee go astray, we should find ourselves in a no less precarious situation.

Therefore, we have prepared this manual against this hypothetical eventuality. There is little or no information available on this subject at the present date, so we approached the problem from the standpoint of an electronics engineer who desires to commit arson or who

desires to cause a criminal explosion. These pages attempt to set forth the basic techniques by which such crimes may be committed, try to show come of the fundamental circuitry involved, try to point out the circumstances in which these methods may be utilized, and attempt to show the investigator what to look for as evidence of this type of crime. The writing makes every effort to be as non-technical as possible, so that the reader not familiar with electronics will be able to understand it thoroughly.

It should also be made clear that the methods herein described are definitely not the only methods that may be used. In relation to the manipulations possible through a full use of modern electronics, they are crude and basic. Endless variations as well as combinations of these circuits exist. New materials and components are being developed that may find use in this area. Component miniaturization is leading to compact devices.

This, then, is a "do-it-yourself manual."

At the outset, it is necessary that we delineate between the term "electrical" and the term "electronic." Electrical devices of many types have been with us for years, and have often figured in the commission of crime. Electronic devices, on the other hand, are of comparatively recent origin, and their incidence in the commission of crime is not known.

By "electrical" we mean the phenomena of an induced current of electricity passing through a conductor and producing a useful effect in the form of heat or energy. An example of an electrical device would be the household iron. In this article, useful heat is produced by the passage of a current of electricity through a resistance unit imbedded within the iron itself.

By "electronic" we mean the emission, or the giving off, of electrons from the surface of a material, and the behavior of this emission as in vacuum tubes, photoelectric cells, solid-state devices (transistors, diodes), etc. An example of an electronic gadget would be the photographic exposure meter. Here, the presence of a certain amount of light causes the emission of electrons which, in turn, cause the movement of a pointer along the divisions of the meter face.

In the interest of simplification, we may say that the operation of any electronic device depends in some way upon the emission of electrons; purely electrical devices do not.

Hence, electronic arson is nothing more than arson in the conventional sense, except for the fact that an electronic contrivance has figured in the initiation of the event.

But why should the incipient arsonist or the criminal planning an explosion bother with such an elaborate method? After all, the candle in a pile of shredded paper or the match applied to a powder trail does an efficient job.

The answer is both obvious and quite simple. He will take the extra trouble necessary because electronics can supply him with certain features desirable to his profession that are not available by other methods.

He will be able to set off his "plant" by remote control, thus enabling him to be many miles from the scene of the crime. If he is seen in some distant city at the time established for the crime, his alibi is nearly air-tight. He may push a button by remote control and initiate the disaster at his convenience, or he may provide suitable delay devices that will do the job for him at a predetermined moment or at a random interval that not even he would know. He may arrange for the crime to be triggered by an unwitting outsider.

He knows that the detection of the method used will be difficult. Few law enforcement agencies can have an electronics specialist at

their disposal, and detection requires that personnel be thoroughly trained in the recognition of significant clues. He knows that electronic devices are becoming more sophisticated and, as a result, are becoming more compact and therefore more easily destroyed beyond recognition in a fire or an explosion.

Best of all he has a wide choice in the method of procurement of electronic apparatus. He may purchase the parts and build a device from "scratch." He may buy a suitable kit and assemble it himself. He may purchase the desired device ready-made.   Whatever his choice, he knows that anyone can buy electronic components or finished units without arousing the slightest suspicion. Aside from the professional people utilizing electronics, each city of any size has hundreds of individual experimenters and tinkerers.

The use of electronics in crime will be most insidious.

This brings us to an important question. Is this method now in use? Is the science of electronics being used to start fires and cause explosions? We have every reason to believe that it is.

During the past several weeks, we have engaged in correspondence with the fire marshals of forty-one states. Many of them corresponded with other law enforcement agencies and national investigators. A few of them flatly stated that they had experienced nothing of this nature. Many others, however, expressed grave concern as to the possibilities raised by the thought of such crimes. Still others went so far as to say that they may have encountered electronic devices in this context but were not able to prove it.

The State of Florida happens to fall into this latter category at this time. At least two fires of suspicious origin were recently investigated by this office. Indications are that at least one of them and possibly both of them

were triggered by electronic means.

One state contacted has been most fortunate in this respect. They managed to catch a potential electronic arsonist red-handed. He was a professional electronics man, and was able to devise a seemingly fool proof scheme. Flammable materials were placed in close juxtaposition to an electronic device consisting of a battery operated radio receiver, an initiating relay connected to the receiver, and a heating coil attached to and activated by the relay.

Theoretically, a pulse was to be sent from a radio transmitter located at some distance from the "plant." The receiver was to pick up this brief pulse and, in turn, the relay was to close, thus introducing electricity into the heating element. This was intended to ignite the flammable material. Many little niceties were included in the plan. All interconnection of the various components was carried out with solder having a low melting point. It was expected, of course, that the solder would melt and dissipate in the ensuing fire and all evidence of arson would, therefore, be destroyed. Unfortunately, there's many a slip between cup and electronics. The "plant" went off according to plan, but the fire was discovered before any severe damage had been done and, more important, before the electronic device used in starting the fire had been destroyed.

All of this seems to indicate that electronics will become one of the modern day tools of arson. Concern should not be manifest over the probability that its use is not particularly wide spread at this moment. It appears certain that if electronics has not already been utilized by a large segment of the criminal element, it soon will be.

II. WHAT ELECTRONIC ARSON HAS IN COMMON WITH CONVENTIONAL ARSON:

New science and technology develop, and new faces indulge themselves in illicit pursuits, but certain fundamental ideas tend to remain constant.

We may expect the basis or the reason for arson by electronics to be much the same as for arson as we now know it.

The desire for economic gain may provide the impetus necessary to cause a person to commit this criminal act. Many ramifications of this single rationale may exist. The gain therefrom may accrue directly, or the gain realized may be so far removed from and seemingly unrelated to the act itself that discovery or proof of the relationship becomes next to impossible.

The grounds for arson may possess no intrinsic validity in its own right, but may be engendered by or be the outgrowth of another offence. The embezzler may choose this method as a handy means of concealing his crime. The murderer finds it expedient that the results of his handiwork should disappear without trace, or at least should appear to have met with misfortune by another agency. The dishonest merchant who has been falsifying records of his assets takes the chance in order to prevent disclosure.

Arson for personal satisfaction may run the whole gamut of human emotions and their many nuances. The disgruntled employee may seek to secure some form of gratification by causing inconvenience or even complete ruin to his employer. Already hardened criminals may find it convenient as a method of beating recalcitrant victims into line. The would-be politico or labor organizer might discover through arson an outlet for his revenge.

Or the arsonist may be a "nut"; i.e., a mental deviate. He may achieve sexual enjoyment from the starting of a fire or from watching the ensuing conflagration and its attendant excitement. He may possess feelings of general hostility or inadequacy which find their outlet in the perpetration of a fire or an explosion. And, in this category, we may find something new. The ancient Romans had a saying, "Ars Gratia Artis," which in modern times, might be paraphrased into the concept of Technology for the sake of Technology. The electronics specialist is a scientist, a mathematician, a man with an excellent knowledge of applied physics. But he is more than this in some instances. He may be an artist in his own right. It seems feasible that such a man, assuming him to have a sufficient mental aberration, might simply like to see his plan work. This could be one of the most dangerous kinds of electronic arson, since the design could be expected to be most abstruse and elaborate.

We may expect to encounter the use of the same materials in the initiation of such fires and explosions as are found by present investigations. The arsonist needs something that is readily flammable or explosive, and most of the materials that have been in use during years past will still provide the desired result. The man with a knowledge of chemistry, however, may wish to branch out a bit in his choice. Pyroxylin plastic, for example, being of such a chemical composition that external oxygen is not necessary to its combustion or decomposition would furnish the fire service with some anxious minutes in the early stages of the blaze. It could not be extinguished by smothering and would, therefore, be difficult to combat without large quantities of cooling liquid. Ammonium nitrate would offer the same hazard. It is easily obtained, carries its own oxygen supply within itself, and gives the arsonist the additional dividend of producing copious quantities of extremely toxic fumes.

Whatever the choice of the material, its general type will be common both to electronic arson and conventional arson.

The circumstances surrounding the actual commission of the crime will supply the final area of correlation between the two types of arson. The circumstances may be identical in both cases, but because of the peculiar advantages offered by electronics, certain associated facts may not be so clear-cut or have such an obvious relationship to the crime. We may expect the relevancy of the integral facts to the crime to be quite abstract in some cases. .

But, sic transit gloria obsolescent arsonist. Electronics has new things to offer.

III. HOW ELECTRONIC ARSON IS DIFFERENT FROM CONVENTIONAL ARSON:

Electronic arson is characterized by certain distinguishing features that set it apart from ordinary arson, and it is these factors that will tend to make it so attractive a method to the lawless element.

The foremost difference, of course, is the manner of triggering the fire or the explosion. This may be as simple or as complex as the individual circumstance may warrant, but the actual triggering will, in all cases, be accomplished by electronic means.

At the less exotic end of the scale we have the straightforward timing devices. These may be electro-mechanical in nature, or may be strictly electronic. They may be an integral part of an existing household appliance. They may be self-contained units, rather bulky by comparison. They may take the form of a tiny, hand-built electronic circuit hidden away in some inconspicuous spot, and prone to destruction by an ensuing holocaust.

At the other end of the scale, in degree of complexity, stand the radio-controlled devices. These may be rather small and unembellished if designed to operate at close range, but may become quite large and somewhat ornate if designed to produce consistent results over a long distance. Equipment associated with the radio paraphernalia will be determined by the ultimate job the mechanism is to accomplish. For example, an unadorned radio system might use a single pulse to initiate an entire fire or explosion. With more supplemental components, a sequential system may set multiple fires or detonate multiple explosions on each subsequent command.

Between these two extremes are encompassed a Pandora's Box of myriad contrivances such as counters, light-controlled switches, moisture sensors, heat and cold sensors, capacitively operated relays, and uncountable combinations of all of these and many more.

The devisor's imagination is quite free to soar to whatever heights of malevolence that he would like to reach. We are reminded of the condition existing during and immediately following World War II, when rugged groups of men were laboring to disarm unexploded bombs that had fallen in populous areas. They succeeded in developing proficient disarming techniques, only to discover that the enemy had devised even more cunning and elaborate trigger systems to prevent easy neutralization. In a like manner, variation in the assembly of these electronic gadgets will permit modification ad infinitum, and this will make detection progressively more difficult.

It is most obvious that arson by electronics will be marked by seemingly mixed-up time and space relationships. The principal suspect may be discovered to be at a great distance from the scene of the crime. Polygraph examination may show that the accused has no actual knowledge as to when the alleged crime occurred. The suspect may be in the company of friends at the time the incident takes place. He may be enroute to some distant point. He may have been absent from the locale for a

number of days prior to the crime. The fire or explosion may take place during the day in the presence of witnesses; it may happen when the site is uninhabited. All of these situations, and many others, become valid propositions when electronics is utilized. It is also certain that the mere establishment of the corpus delicti will be exceedingly difficult when such means are employed.

Arson by electronics may be presumed to be of an inherently more elaborate nature than conventional arson. It also follows that the criminal himself may be expected to be of a more intelligent and more highly educated type. It is true that a portion of the people employed by the electronics industry are purely theoreticians and therefore do not necessarily possess the practical ability to implement such plans, but many of them are craftsmen, not only in electronics, but in allied arts such as chemistry, physics, and machine tool practices. In these cases it would be unnecessary for them to acquire outside help, thus restricting intimate knowledge of the offense to a minimum number of persons.

One item of equipment peculiar to arson or explosion by electronics may be expected to be found in common with all such crimes. We refer to the relay. The relay is actually nothing more than an electrically operated switch, by means of which a relatively large amount of voltage or current may be controlled by a very small amount. It consists of two fundamental parts; the actuating coil or solenoid that moves the contact section built into the unit, and the contact arrangement itself whose function is to either break or complete an external circuit. The relay is available in any number of shapes, sizes and current handling capacities, and in a great variety of assorted contact and coil configurations. It is low in cost, and can be secured from thousands of sources. Its general appearance is something like this. (Fig. 1)
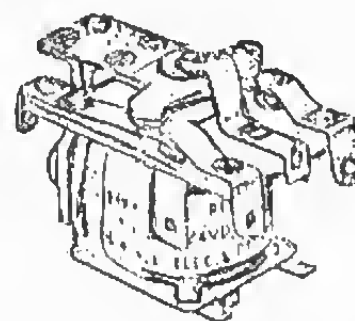
In the case of most electronic components, it would be too clumsy a procedure to draw a pictorial representation of a part every time it was desired to show the use of the part in a circuit. Instead, a schematic equivalent or symbol of the component is used.

Figure 1.

contacts

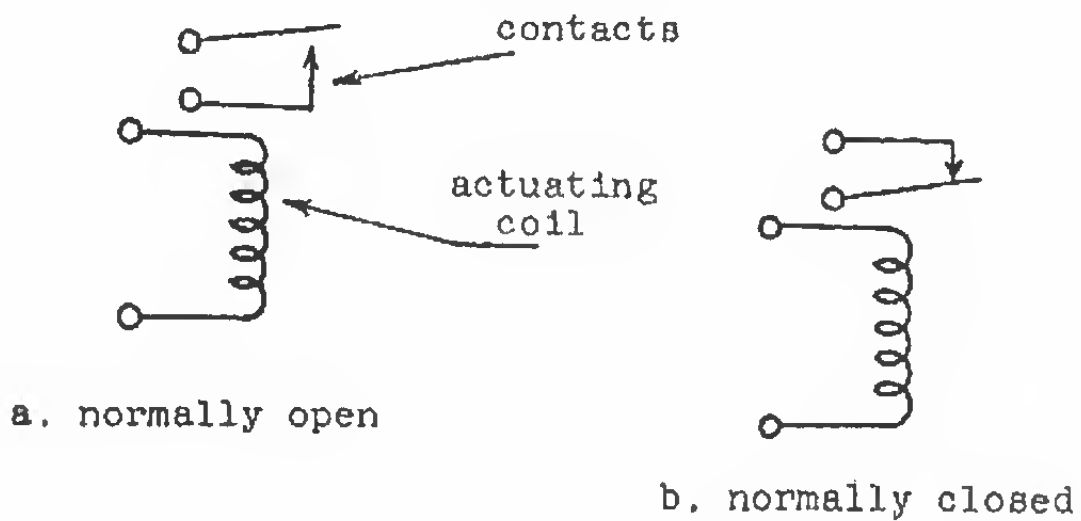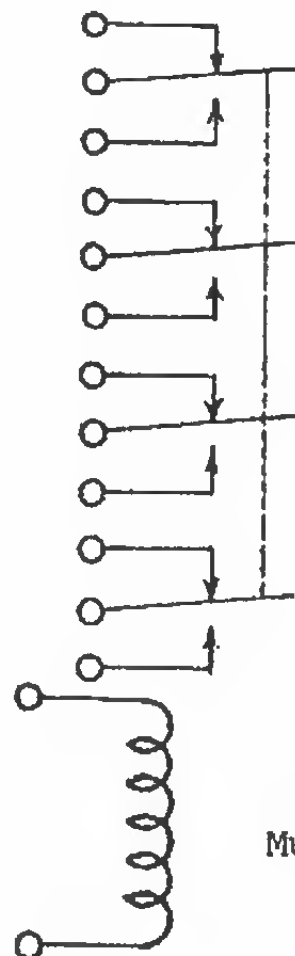actuating
coil

a. normally open

b. normally closed
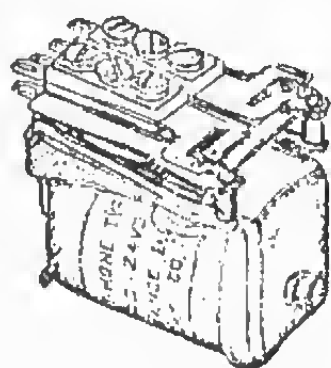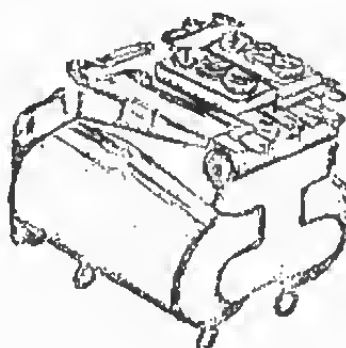
Figure 2.

All armatures (parts
connected with dotted
line) move at the same
time.

Multiple contact relay

Figure 3.

Regardless of the type of relay, two basic contact arrangements are commonly found, and are depicted schematically like this. (Fig. 2)

Operation of the device is easy to understand. A pulse of electricity is sent through the actuating coil, causing it to become an electromagnet. This action pulls the contact assembly toward the pole piece of the electromagnet, and thus closing the points as in figure 2b. By this means the external circuitry is either completed or broken.

Relays incorporating rather bizarre contact formations, such as the multiple contact relay, may be secured. This unit makes possible the simultaneous activation of several circuits. (Fig. 3)

Sequential or stepper relays are also quite common. Every time an individual pulse of electricity reaches this type of relay, succes-sive external circuits are operated. (Fig. 4)

Following a fire or an explosion in which the use of an electronic device is suspected, it is quite possible that the remains of a relay will be present in the debris near the point of origin of the event. Several different types of rare metals are often used in the production of relays, and some of these materials possess a high melting point.

The actuating coil of the relay, although usually wound with small copper wire, is not easy to destroy. It presents a somewhat dense mass, being made up of a great number of turns of wire, and is usually provided with a solid iron or steel center or core.

Following, is a list of some of the relay parts that might be recovered after an incident, together with a list of the materials from which these parts are commonly made, and the melting point of each substance.
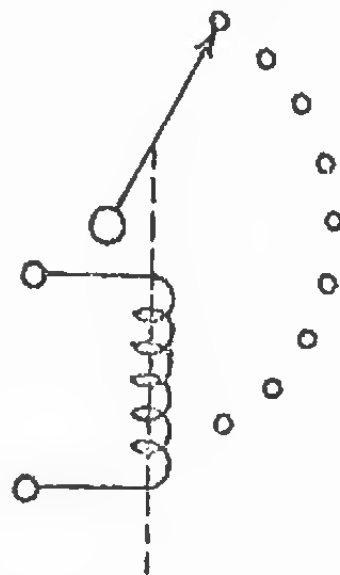
Contacts advance one position only with each activation of the coil.

Sequential or stepper relay

Figure 4.

Actuating coil - - - - - - - - usually wound on some kind
of phenolic bobbin or form
wirh iron or sreel center.
Winding of copper wire, most
ofren insulated with enamel.

Melting points

Copper - - - 1981 degrees Fahrenheir

Iron & Sreel - - - 2200 to 2800
degrees Fahrenheit

Contact points - - - - - - - - ofren made of silver, gold-flashed
silver, plarinum, palladium.

Melting points

Silver - - - 1700 to 1800 degrees
Fahrenheir

Gold - - - 1950 degrees Fahrenheit

Platinum - - - 3223 degrees Fahrenheit

Palladium - - -2882 degrees Fahrenheit

Contact arms - - - armature hinges - - - usually of brass or
beryllium copper.

Melting points

Brass - - - 1700 degrees Fahrenheit

Beryllium - - - 2343 degrees Fahrenheit

Consideration should be given to the fact that rhese materials will not instantaneously achieve a melted state upon exposure to the indicated temperature; the time required for melting will be a function of the amount of the material present and its particular physical shape.

Just as a symbolic representation of the relay has become the accepted method of depicting that component in an electronic circuit, so have similar figures been adopted as the means of showing other parts. It is not intended that this manual should go into electronic theory, but it seems advisable that the reader should be conversant with some of the funda-

menral notations used in rhe basic hook-ups. Here then, is a lisr of the more common electronic components; their schematic equivalent, and rheir actual appearance. No attempt has been made to show these articles in any relation to their true size. Many of rhem are made and used in sizes ranging from extremely small to very large. Those interested in the precise function of these parts and their associated circuitry are referred to any standard text on the subject such as the RADIO AMATEUR'S HANDBOOK. (Fig. 5)

IV. INITIATING MEDIA AND INITIATORS:

In the perpetration of any arson, it is necessary that some flammable material be abundantly available. This is equally true of the origination of a criminal explosion for actually, there is no clear-cut line of demarcation between fire and explosion. The only differentiation is as to rate of burning; i.e., rate of oxidation. According to the accepted understanding of the term "burning," ordinary flammable substances enter into combination with oxygen at a fairly rapid rate. When this rate becomes fast enough, the materials are referred to as "low" or "deflagrating" explosives. Finally, the rate increases to the point

a. wires crossing but
not connected

b. wires crossing but
connected

Figure 5.
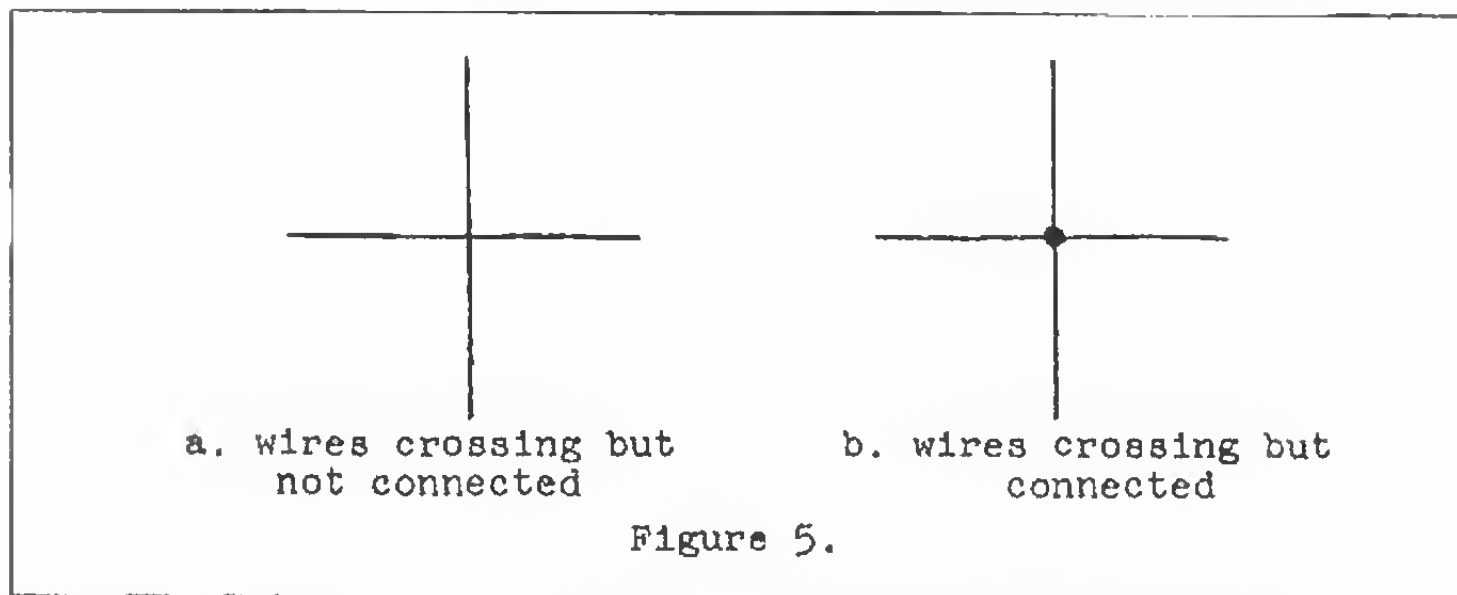
where the usual terminology is no longer applicable, and the expression "detonation" applies. In some situations, such as the burning of gasoline vapor, it is most difficult to categorize the incident. Sometimes the phenomenon is termed "explosion"; sometimes "flash-fire"; at other times, just plain "fire." In any case, the fundamental chemical reactions are identical except as to rate.

If the destruction of a specific building is desired, some initiating medium must be employed. One of the tribulations associated with the arsonist's life is the fact that certain materials can be disgustingly difficult to ignite. He cannot simply apply a match to the leg of a chair and expect it to burn. Most

Figure 5. c.

Component	Schematic Symbol	Actual Appearance
Fixed resistor		
Variable resistor		

Figure 5. c.
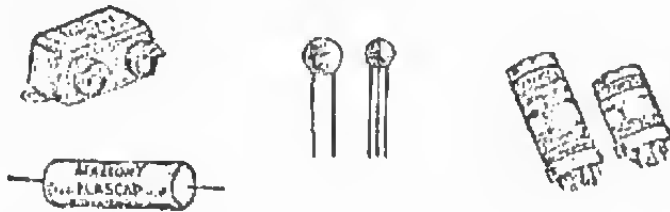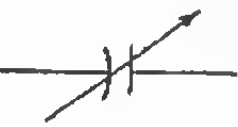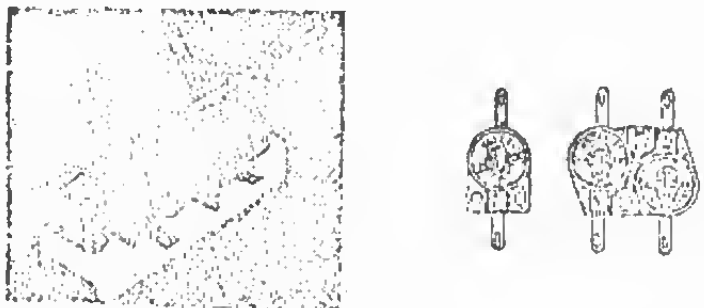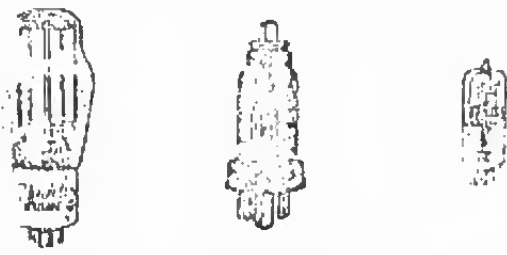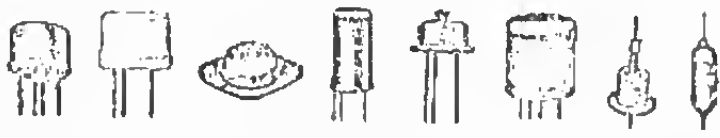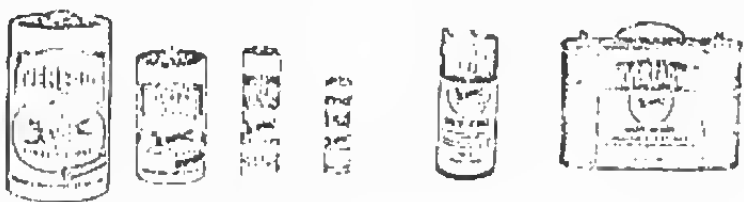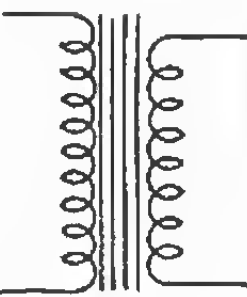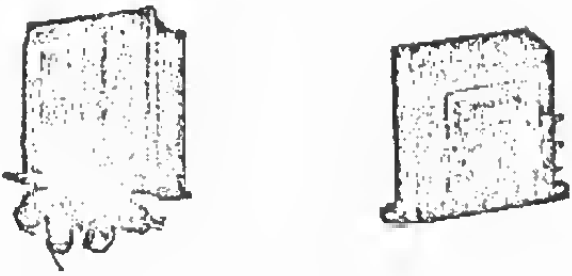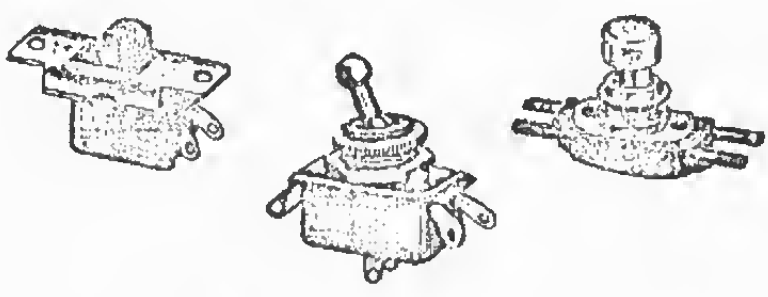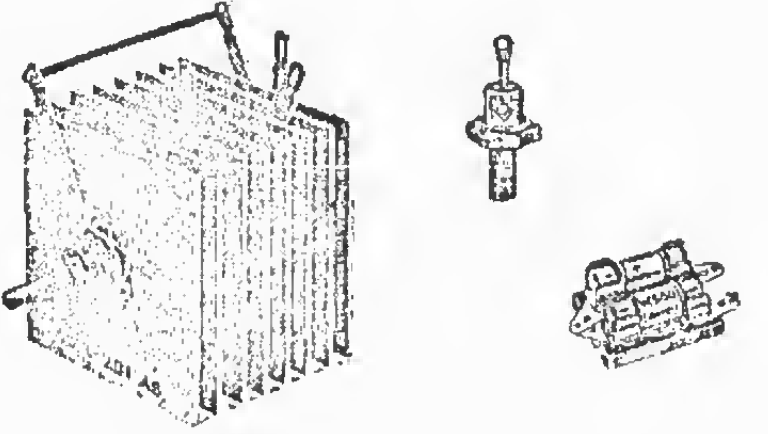
Component	Schematic Symbol	Actual appearance
Fixed capacitor		
Variable capacitor		
Vacuum tube		
Transistor		
Battery		
Transformer		

Figure 5. c.

Component	Schematic Symbol	Actual appearance
Switch		
Rectifier		

woods will withstand a temperature of approximately 750 degrees Fahrenheit for a period of 20 to 30 seconds before igniting.

In addition, several other factors must be taken into consideration. In the burning of most substances, actual combustion takes place only after the solid or liquid fuel has been decomposed or vaporized sufficiently by heat to form a flammable gas. Ignition occurs only when there is present a favorable combination of suitably high temperature and a large enough quantity of heat to initiate self-sustained combustion.

A fire can be self-sustaining only where there is fuel, an oxidizing agent, and a temperature that remains high enough to maintain combustion. The match flame is very hot (about 2000 degrees Fahrenheit) and should, therefore, be capable of igniting the chair leg. This level of heat, however, cannot be sustained; the adjacent wood conducts much of the residual heat away from the point of origin, and combustion does not occur. It soon becomes apparent that some substance more readily flammable must be utilized to start such a blaze.

The ignition temperature of ordinary combustible materials, or the minimum temperature required to cause self-sustained combustion independent of the external heating agent, lies between 300 and 1,000 degrees Fahrenheit. Furthermore, the actual ignition temperature of a given material varies considerably with the physical form of the material. Usually, the smaller the particles of the substance, the lower the ignition temperature. Shredded or cut paper will ignite more readily than tightly rolled or tightly bound newsprint. The vapor of a combustible liquid, being in individual molecular form, will ignite more quickly than a tub full of the material. A fine cloud of combustible dust will ignite quite easily with a comparatively small a-

mount of heat from a mechanical or an electrical spark.

Certain other rather stringent limitations are attached to flammable solids and liquids as to the precise conditions under which they will burn or explode. The explosive or flammable limits of a material refers to the ratio between the amount of potentially flammable vapor in mixture with ambient air or oxygen. The lower limits are defined as the minimum concentration of vapor in air or oxygen below which the propagation of flame does not occur on contact with a source of ignition. Likewise, there is a maximum concentration *above* which ignition does not occur. As may be expected, these limits have wide variation dependent upon the particular material involved.

Where a flammable liquid is used, the flashpoint of the substance is an important factor. This is the temperature to which the liquid must be heated so that it gives off sufficient vapor to form an ignitible mixture with the air near its surface. The fire-point, normally a few degrees higher, is the temperature at which the vapors are evolved fast enough to support continuous combustion.

From the standpoint of a purely chemical reaction, all or most of these criteria must be fulfilled before an active blaze can begin and continue. An arsonist's life is not a completely happy one.

Therefore, before he can commit a crime of this type, he must provide an initiating medium that will ignite quickly and reliably at a rather low temperature. Upon ignition, it must progress rapidly to a reasonably high temperature, and it must sustain that temperature peak until the ignition of surrounding material takes place. If he can arrange for this medium to disappear following combusiton, so much the better.

Herewith is a list of some materials that fulfill most of these parameters, together with the approximate ignition temperatures of each substance, their flammable and explosive limits, and pertinent data peculiar to each material.

---

1. Shredded materials:
   a. cut newspaper - - - ignition temperature 446 degrees F.
   b. cut filter paper - - - ignition temperature 450 degrees F.
   c. excelsior- - -
   d. straw - - - - -   - - - ignition temperature 450 to 500
   e. sawdust - - -   degrees F.

   All of these materials should be placed in a rather loose mass in order to permit free access of oxygen to the material.

2. Liquid Hydrocarbon Fuels:
   a. gasoline - - - - - ignition temperature 536 to 800 degrees F. depending on the octane rating

      flash point minus 45 degrees F.

      explosive limits: (percentage of vapor in air by volume):

      upper limits 7.6%
      lower limits 1.4%

b. kerosene - - - - - ignition temperature 480 degrees F.
(No. 1 fuel oil)

> flash point 100 degrees F.
>
> explosive limits (percentage of vapor in air
>   by volume):
>
> > upper limits 5%
> > lower limits 0.7%

3.   Gaseous Hydrocarbon Fuels:
a.   natural gas - - - - - ignition temperature 1,000 to 1,200
   degrees F.

> explosive limits (percentage of vapor in
>   air by volume):
>
> > upper limits 15.0%
> > lower limits 4.5%

b.   LP gases - - - - -

1.   propane - - - ignition temperature 871 degrees F.

> explosive limits (percentage of vapor in
>   air by volume):
>
> > upper limits 9.5%
> > lower limits 2.2%

2.   butane - - - ignition temperature 806 degrees F.

> explosive limits (percentage of vapor in air
>   by volume):
>
> > upper limits 8.5%
> > lower limits 1.9%

Strictly speaking, propane and butane might well be classified
as liquid fuels, since they are normally stored as liquids under
pressure, but utilized as gases.

4.   Paints and Lacquers:

Ignition temperature may be anywhere from 475 to 1,000 degrees F.

Flash-point usually 80 degrees F. or lower.

The flammable part of these materials is not the pigment, although
certain metallic chromate pigments are, in themselves, flammable.

Combustion takes place in the oils, solvents, vehicles and thinners.
Some of these, depending on the type of paint or lacquer are:

> Amyl Acetate - - - - - - - - - - - ignition temperature 715
>   degrees F.

Acetone - - - - - - - - - - - - - - - ignition temperature 1,000 degrees F.

Linseed Oil - - - - - - - - - - - - - ignition temperature 650 degrees F.

Mineral Spirits - - - - - - - - - - - ignition temperature 473 degrees F.

Petroleum naptha - - - - - - - - - ignition temperature 475 degrees F.

Alcohols - - - - - - - - - - - - - - - ignition temperature 750 to 900 degrees F.

Turpentine - - - - - - - - - - - - - ignition temperature 464 degrees F.

5.   Alkali Earths and Metals:

a. Magnesium - - - ignition temperature 1,204 degrees F. but may be as low as 900 degrees F. if the material is in finely divided powder form.

Cannot be extinguished with water or CO_2. The oxygen in both of these materials feeds the reaction and the fire becomes more intense. Suppression of the blaze can be accomplished only with large quantities of dry sand, dry NaCl, or dry soda ash. Magnesium is easily obtainable, but may be extracted from certain photographic flash-bulbs to avoid detection.

b. Sodium - - - provides a reaction with water.
Also reacts violently with inorganic acids. Its reactive process is:

$$2Na + 2H_2O = 2NaOH + H_2$$

c. Potassium - - - undergoes the same reaction, only more violently than sodium. Its process is:

$$2K + 2H_2O = 2KOH + H_2$$
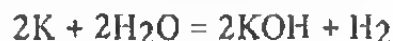
6.   Explosives:

a. Black Powder - - - would not be used as an explosive in this application, but as a connecting link to

ignite several initiatory sources. Ignites within the same temperature range as the afformentioned substances.

b. Primacord - - - a detonating fuse with a PETN core. Decomposes at a rate of 21,000 feet per second. May be used to ignite many initiatory sources simulataneously.

c. Explosives - - - choice of type will vary with the result intended. High detonation speed will give a shattering or a cutting action; low speed will result in a heaving action.

1. Gelatin dynamites - - - detonation speeds up to 22,300 feet per second

2. Straight dynamites - - - detonation speeds up to 18,200 feet per second

3. Blasting dynamites - - - detonation speeds up to 3,900 feet per second

4. Nitro-carbo-nitrate - - - ammonium nitrate-fuel oil mixture. Produces a heaving action, but is the most easily obtained without attracting attention. Also burns readily in natural state, being composed of 60% oxygen. Because of this feature, cannot be extinguished by smothering.

After the initiating medium has been placed at the point where the fire or the explosion is to take place, an initiator must be introduced. This is a device whose function is to set the material ablaze or to institute the explosion. One criteria required of all such initiators in electronic arson is that it must be possible to operate the unit electrically. Manual operation under such conditions is neither practical nor desirable.

The devices that could be used as initiators are myriad, but the following list mentions only those that are commonly available, and especially those that can be obtained without attracting undue suspicion.

1. Calrod-type electrical heating units: These are found on most modern elec-

tric ranges, are the usual type of heating element in household ovens, and are sometimes utilized in small electric hot-plates. They will provide heat at their surface well in excess of 1,000 degrees F. when they are operated to their full capabilities. These units are often supplied with a calibrated temperature control switch, but the surface temperature can be approximated by observation of the color of the unit.

Table of Heat Colors

Yellow	450 degrees F.
Brown to Purple	550 degrees F.
Blue	600 degrees F.

Faint Red	900 degrees F.
Dark Cherry	1,100 degrees F.
Full Cherry	1,400 degrees F.
Salmon	1,600 degrees F.
Lemon	1,800 degrees F.
White	2,200 degrees F.
Sparkling White	2,400 degrees F.

2. Nichrome wire:
    Wire of this variety is, in actuality, an electrical resistance. When a current of electricity is passed through a length of the wire, heat is produced. Most nichrome wire, like the more modern calrod-type units, will produce surface temperatures in excess of 1,000 degrees F. Nichrome wire may be purchased in almost any length desired or if secrecy is important, it may be removed from small heaters and toasters. It is also often found in the cheaper hot-plates, being embedded in a moulded refractory plate.

3. Household fuses:
    Ordinary protective fuses of the screw-in type can be made to serve as an efficient initiator for black powder. The end window of the fuse is first removed, exposing the fusible link. The altered fuse is then wired directly across a circuit into which 115-volt alternating current can be introduced. Black powder is piled on the fuse, making certain that some gets in direct contact with the interior link. When the circuit is closed, the fuse forms a short circuit to the current path. The fusible link then ruptures with a flash quite sufficient to ignite the powder.

4. Photographic flash bulbs:
    Besides serving as a source for initiatory media, the photographic flash bulb also makes a good initiator for powder trails. The bulb chosen must be of the type filled with magnesium. Certain flash bulbs are filled with aluminum foil and are then charged with oxygen. The latter cannot be used as the aluminum will not produce a flash of adequate magnitude once the oxygen has been liberated. The glass bulb is carefully broken away, leaving the fusible element and its accompanying magnesium charge exposed and undisturbed. The element and its magnesium fuel are inserted in a pile of powder. When a current of electricity is passed through the remains of the bulb, a violent flash will ensue, igniting the powder.

5. Electric squibs:
    Normally used for the ignition of powder charges in blasting operations, the electric squib (not to be confused with an electric blasting cap) is ideal for the initiation of powder, flammable liquids or explosive vapors. Physically, the squib is an aluminum tube of small diameter and about 7/8 of an inch long. A charge of deflagrating mixture is enclosed within the tube together with an electrically fired ignition charge. When an electrical current is applied to the wires embedded in the ignition mixture, the compound flashes, the aluminum shell ruptures, and an intense flame bursts forth. Only a small amount of current, in the order of 1/4 ampere, is required to fire the squib.

6. Electric blasting caps:
    The No. 6 electric blasting cap is the one most commonly used industrially. It is similar to the electric squib, except that its ultimate object is detonation and not deflagration. In form, it is slightly longer than the squib, about 1 3/8 inch, but contains a high explo-

sive base load such as tetryl, a pressed primer load of lead azide, and a loose ignition charge. Wires are embedded in the ignition charge, and are bridged at their extreme end with a small resistance wire. When current is passed through the wires, the resistance element heats immediately to incandescence and a chain of ignition is begun ending in detonation. The final detonation of the cap is enough to cause detonation in most dynamites and gelatins. Two of these caps taped tightly to the end of a piece of primacord will ensure its sudden and violent decomposition.

7.   Electrical sparks:

Either electrical or mechanical sparks can easily cause the ignition of flammable vapors. A relatively small amount of heat is necessary since the compounds involved are in widely dispersed molecular form. Mechanical sparks, although they often generate a heat equal to or above 2,000 degrees F., are not practical for such purposes because of the difficulty in generating them with any semblance of reliability. Electrical sparks, conversely, are readily generated and, depending on the generating voltage and amperage, may reach temperatures of 7,000 degrees F. or higher.

A most efficient spark generator is the rather ancient model "T" spark coil. This unit, originally used in the ignition system of that venerable vehicle, made use of a vibrating tongue to make and break the circuit of an induction coil. When attached to a battery, the unit will create a continuous series of sparks at a potential of better than 12,000 volts. In the operation of the device, there is considerable spark-

ing at the points of the vibrating reed. These may be used, or a conventional spark gap may be attached to the external terminals, thereby producing a longer spark.
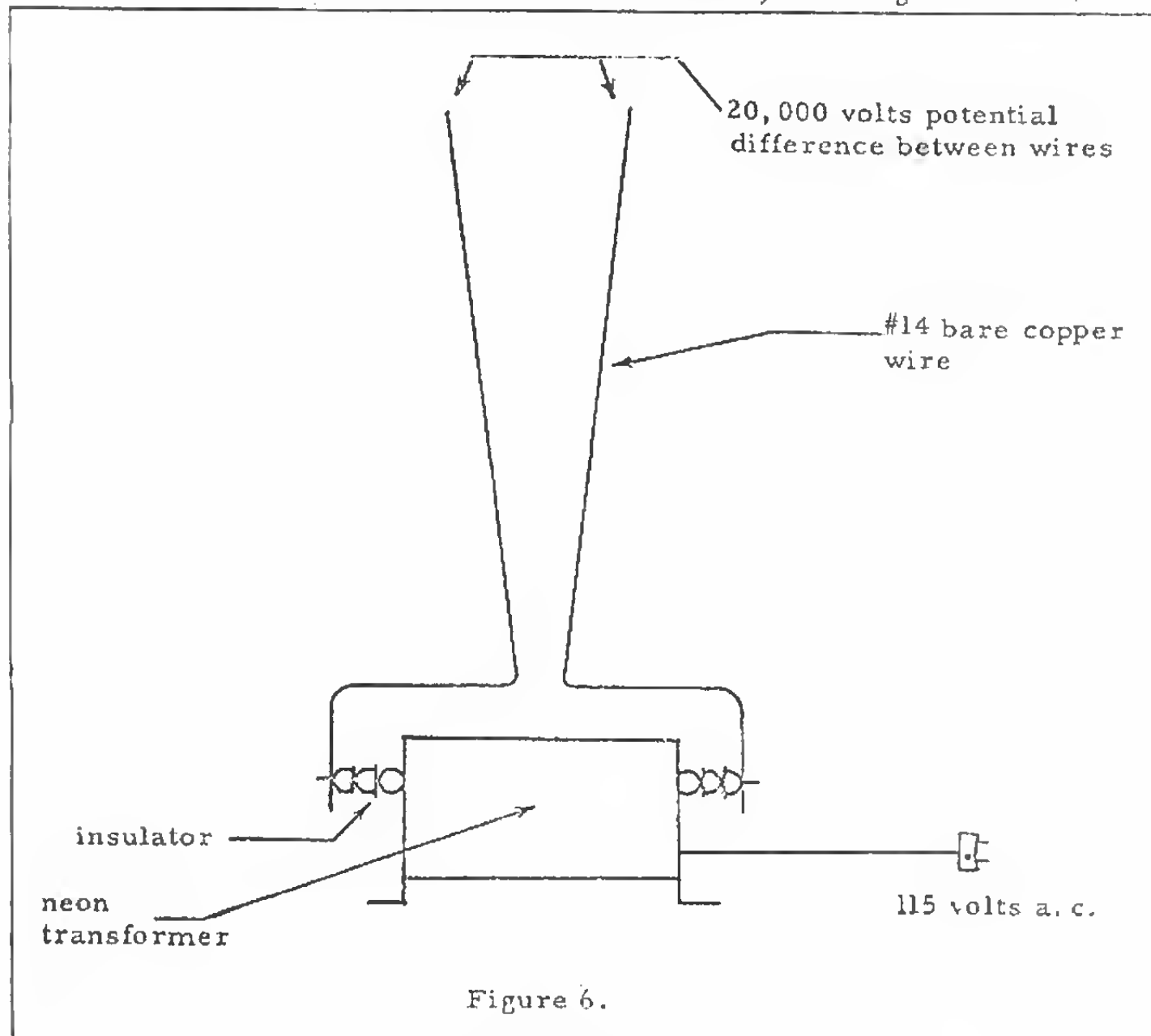
An interesting variation of this type of initiator is a specific application of the neon sign transformer. Potentials of 20,000 volts or higher may be obtained from these units. The transformer is rather heavy and bulky and can be used as the support, as well as the voltage supply for a horn gap. This device is often encountered in horror movies, since it makes a somewhat impressive and eerie display, but it will also provide a recurring spark of great intensity. The principle of the horn gap is utilized commerically in providing lightning protection for broadcasting stations and for power transmission.

The horn gap may be quickly constructed with a neon sign transformer and two coat hangers, although bare copper wire of about size 12 will be better adaptable. If the coat hangers are used, the paint should first be removed from their surface with some type of abrasive material. Two lengths of the wire, each about 24 inches long, are bolted to the opposite high voltage terminals of the transformer. The wires are then bent in such a way that they are close together near the ends fastened to the terminals, and so that they slowly diverge toward their extremities. The minimum distance of the wires will have to be determined by trial and error, but it should be small enough so that an arc is struck immediately when the transformer is energized. The angle at which the wires diverge   should be gradual.

(Fig. 6).

The action of the horn gap is simple. When household current is applied to the primary windings of the transformer, a high voltage is induced in the secondary winding. Immediately, an arc jumps between the two wires at the point of closest proximity. The arc is maintained, and slowly and steadily rises along the wires. Be-

20,000 volts potential difference between wires

#14 bare copper wire

insulator

neon transformer

115 volts a.c.

Figure 6.

Lamp Size	Surface Temperature of Bulb	Filament Temperature
40 to 100 watt	200 degrees F.	4,550 degrees F.
150 to 200 watt	295 degrees F.	4,725 degrees F.
300 to 500 watt	380 degrees F.	4,830 degrees F.
250 watt heat lamp	400 degrees F. or higher	

coming longer as the wires diverge. By the time the arc has neared the top of the gap, the spark is quite long and quite hot, sufficient to ignite almost any flammable or explosive vapor. When the arc finally breaks because the spacing of the wires becomes too great to permit the available voltage to bridge the gap, a new arc forms at the narrow portion of the wires, and the cycle repeats itself.

8. Incandescent bulbs:
Common electric light bulbs serve as excellent initiators for sawdust, some types of thin paper, and powder. Certain conditions must be imposed, however, if they are to prove effective and reliable.

When in operation, the surface temperature achieved by even a bulb of modest size is rather high, and the temperatures reached by the filaments of even a small bulb are astronomical.

If the bulb is left exposed, even though lying on flammable materials, it is not certain that ignition of the material will take place. A red-hot soldering iron will reduce paper to ash without achieving ignition if it is left lying on the paper while it is heating. On the other hand, if the iron is up to maximum temperature before making contact with the paper, ignition will occur at once. This is also true in the case of the exposed bulb, since much of the heat is dissipated into the ambient air.

Even a 25 to 40 watt bulb, if tightly wrapped in several layers of tissue paper or buried in finely divided combustible material will reach a temperature of 800 to 900 degrees F. within 20 to 30 minutes. A larger bulb will accomplish this amount of heat more
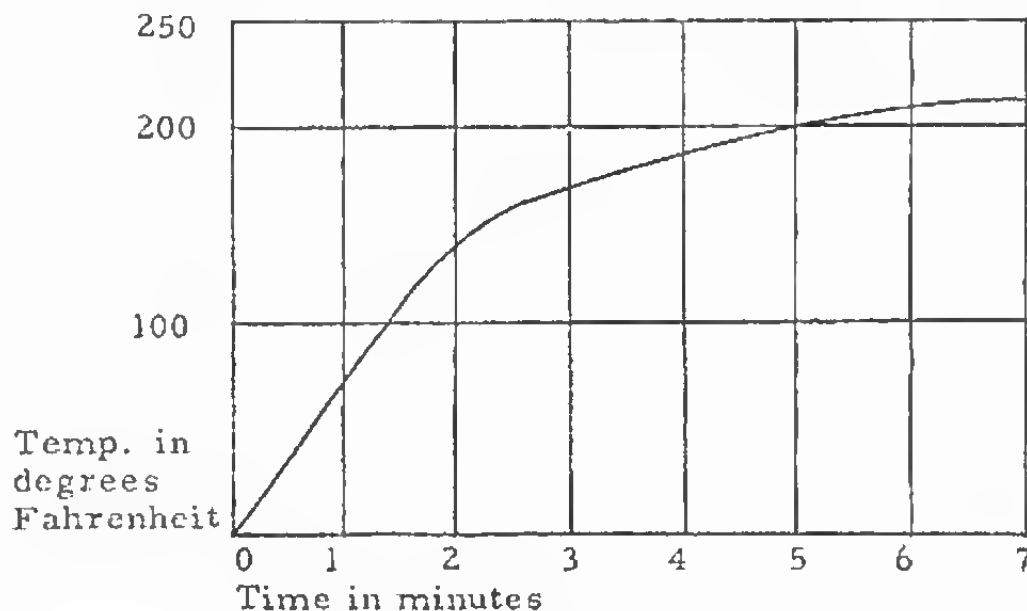

Figure 7.

Rate of temperature increase
on surface 6" from 250 watt
infra-red heat lamp.

rapidly. If the time element is extended, it is very possible that the bulb will rupture. Electric light bulbs begin to lose their shape after 10 minutes exposure to temperatures of 900 degrees F. or more, and shortly after this, the glass envelope will begin to flow. When this happens, the outer covering of the bulb loses its integrity and the extremely hot filament may come into direct contact with the flammable material. The heat lamp is constructed of heavier glass, and because of this factor, the probability of the heat lamp achieving this state should not be anticipated.

The infra-red heat lamp can also function as a valuable adjunct to the initiatory process. If the use of one of the less volatile flammable liquids is contemplated in conjunction with a continuous spark-type initiator, the lamp, focused on a container of the liquid, will cause rapid evolution of

flammable or explosive vapor. Quite a bit of heat is generated at the surface of the substance if the infra-red bulb is aimed at its surface at close range. At a distance of six inches, the heat rise, and the time required for this amount of heat rise, are illustrated by the foregoing graph. (Fig. 7)

Temperatures fully adequate for the purpose may be quickly generated even in a cold room, since radiated heat is not absorbed by air to any extent, together with the fact that heat radiation is largely in the red and the infra-red portions of the spectrum.

9. Electromagnets:

The electromagnet as an initiator is something of a paradox. It provides the fundamental principle of the relay, does not produce heat in any appreciable amount, and yet is very applicable to the practice of arson. Its physical makeup is exactly the same as the core of the relay, except that it

Figure 8.
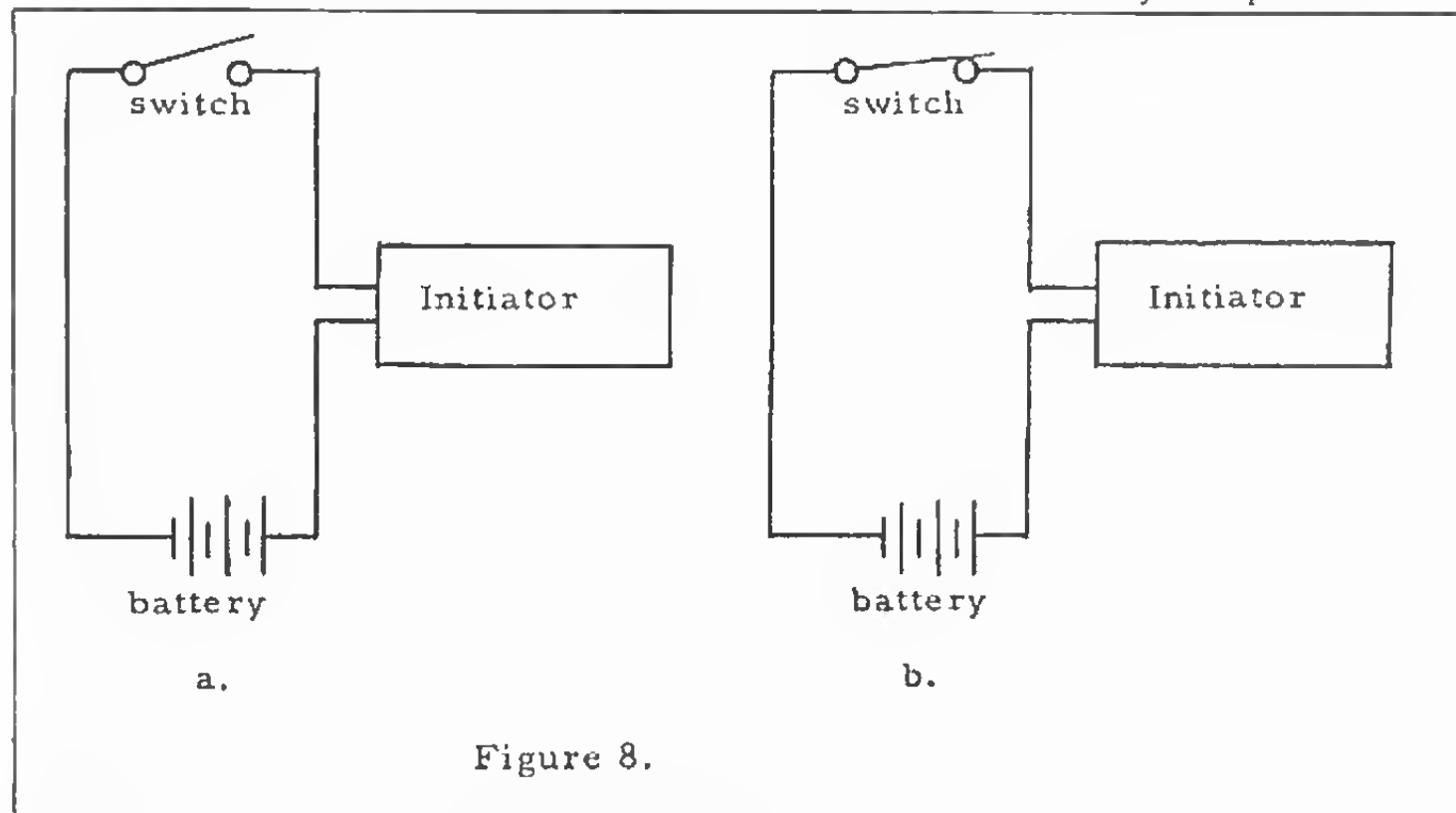
is usually larger and more powerful. It consists of a great number of turns of insulated wire wound on a core of soft iron. When electricity is passed through the wire, the core becomes magnetic and remains so until the current is broken.

Its value in arson lies in its ability to mix dissimilar chemicals on command. One chemical is merely placed in a metal container and suspended above the other by a continuously energized electromagnet. When the current is removed, the container falls and the incident takes place. Variations of this technique will be discussed in the sections to follow.

V. BASIC CIRCUITS:

Up to this point, much attention has been given to materials that will burn or explode, and to devices that will set them afire or detonate them. These items are, in essence, the fundamental building blocks of any arson or explosion and, in the case of the initiators mentioned, more peculiar to electronic arson.

Once these inherent needs have been fulfilled, the electronic aspects of the problem begin to take precedence.

The basic requirement in the employment of the initiating media and the initiators catalogued, is that a switch be opened or closed to begin the operational sequence. A source of electrical power must also be present, as all of the initiators listed are necessarily operable by remote control.

The two essential circuits, the primogenitors of all circuits that can find use in electronic arson, are shown in figure 8.

In figure 8-a, the initiator is activated when the switch is closed; in figure 8-b, the initiator functions when the switch is opened. The choice of the particular circuit used will depend upon the choice of initiator. In both of the illustrations, a battery supplies the power necessary, but the electrical supply may be drawn from a generator or from a power line.

One detail, unfortunately, makes these circuits unsuitable for use in electronic arson. This is the fact that the switches must be moved manually. Luckily, there is an easy
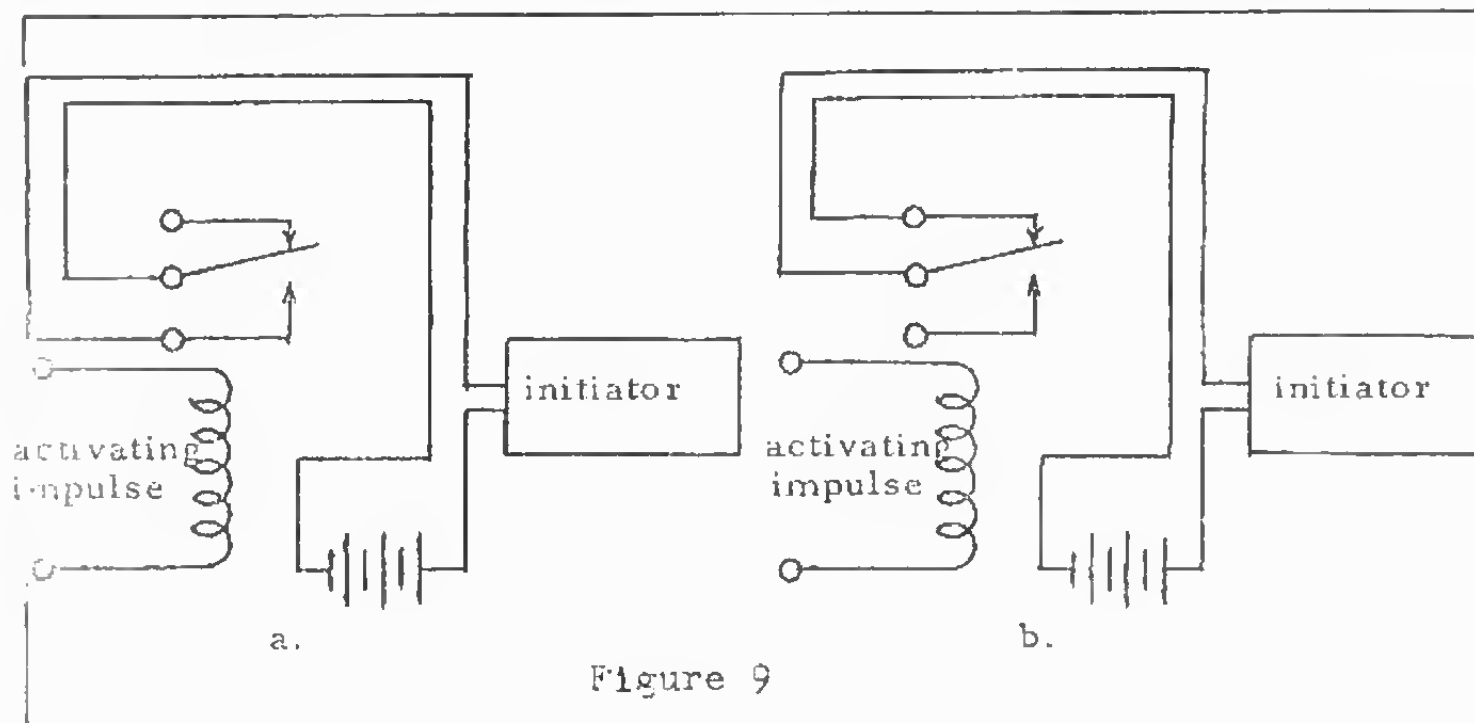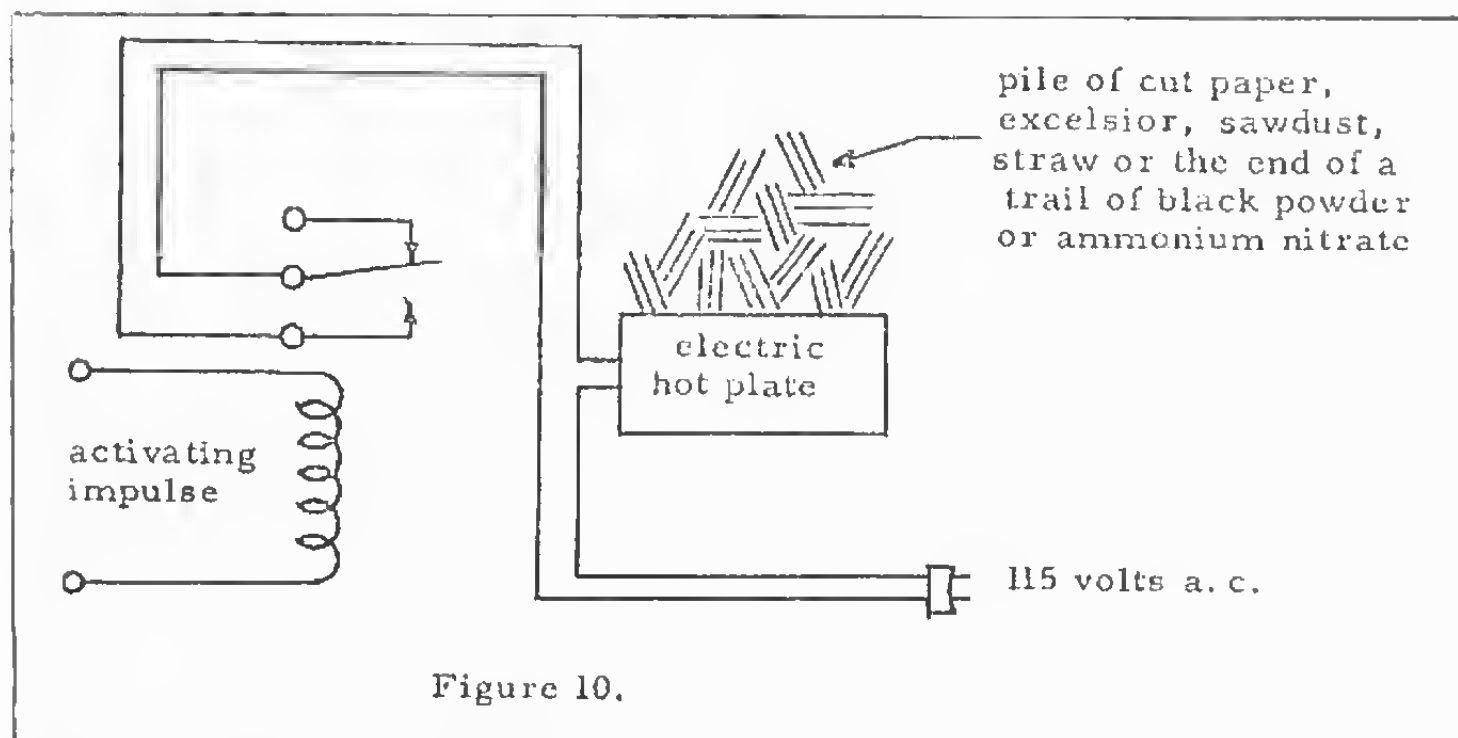

Figure 9

pile of cut paper, excelsior, sawdust, straw or the end of a trail of black powder or ammonium nitrate

electric hot plate

activating impulse

115 volts a. c.

Figure 10.

way out of the dilemma. Both circuits can be readily synthesized into a different form, an electrically operated relay being substituted for the switch. (Fig. 9)

Here, an impulse from an electronic trigger mechanism energizes the relay, closing the lower pair of contacts in figure 9-a, and opening the upper pair of contacts in figure 9-b.

Although the list of initiating media and initiators is far from being completely comprehensive, many combinations and permutations of these devices and materials may be evolved. Consummation of the crime by electronics being the object, a relay must, in all instances, do the switching.

The circuit shown in figure 10 would probably provide the simplest method of originating an arson.

In such an application, the initial impulse closes the lower set of contacts on the relay, introducing 115 volts of electricity into the hot plate heating element. The plate comes quickly to maximum heat, igniting the flammable material.

In this particular situation, it is compulsory

that a latching or a self-holding relay be utilized, otherwise a continous activating voltage would be required. Since it is most expeditious that triggering be accomplished by a single impulse, the ordinary relay would not be desirable. Latching relays (those that lock closed on a single impulse) are easily obtained, but a self-holding relay may be improvised by using a multiple contact relay. (Fig. 11)

As shown in this diagram, both sets of relay contacts move simultaneously when the initiating push button is momentarily depressed. The top contacts function the same as those in figure 10, but the bottom pair, upon closing, feed a constant voltage to the activating coil, thus making it "self-holding"; that is, the contacts remain closed. In the interest of simplification, subsequent circuits requiring the use of such a relay will not show the additional wiring needed; the relay will be merely labeled "latching" or "self-holding."

The modern electric range or oven would furnish a ready-made and self-contained method of arson, a method analogous to the foregoing circuits. Flammable materials may
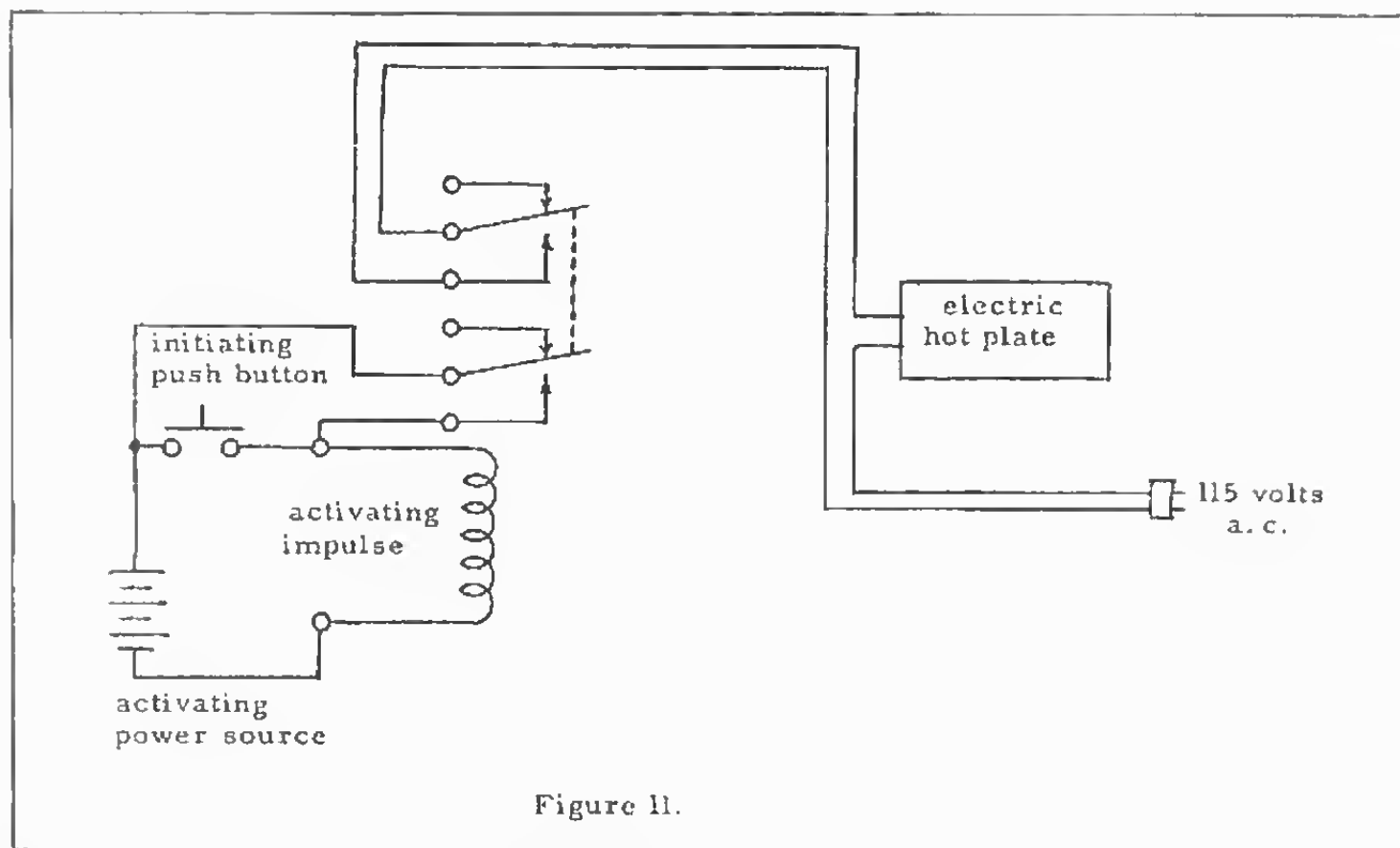
Figure 11.

be piled on the surface of the range, or flammable trails may be led from the heating element in an electric oven and the "plant" triggered with the oven's integral timer. A tightly closed gallon can of paint or lacquer brought to high heat in an open oven, will burst and scatter the burning material with disasterous results.

Variations of the circuits already shown are depicted in figures 12-a and 12-b. It is not essential that a commercial heating unit be used, as it is possible to purchase random lengths of nichrome wire. As mentioned earlier, this wire may also be removed from heaters and some hot plates. In these set-ups, the nichrome wire glows red shortly after the application of an electrical current, and the flammable material promptly ignites.

The "plant" in figure 12-b requires the use of plastic containers for the flammable liquid. The *plastic* will disintegrate rapidly under the heat, thus liberating the liquid to come into direct contact with the red-hot wire. Care should be taken that the plastic container chosen does not disintegrate prematurely under the action of the liquid itself.

It should also be kept in mind that nichrome wire has a finite amount of electrical resistance. Caution must be exercised that too great a length of the wire is not used for the power available. Too much resistance in conjunction with too little power will be manifested in too low a temperature capability of the initiator. Failure will be the end product.

Following a fire set with one of these contrivances, traces of the relay may be found in the residue. The frames of some hot plates might be of steel heavy enough to survive. Portions of the heating elements or the nichrome wire might be found, since they are built to withstand greatly elevated temperatures. If the hot plate utilizes nichrome wire embedded in a moulded retainer of refractory ceramic, it is almost certain that pieces of this

nichrome wire buried
in cut paper, excelsior,
sawdust, straw or the
end of a trail of black
powder or ammonium
nitrate.

activating
impulse

latching or
self-holding
relay

115 volts a.c.

Figure 12-a

nichrome wire wrapped
tightly around plastic
bottle of gasoline,
kerosene or other
flammable liquid.

activating
impulse

latching or
self-holding
relay

115 volts a.c.
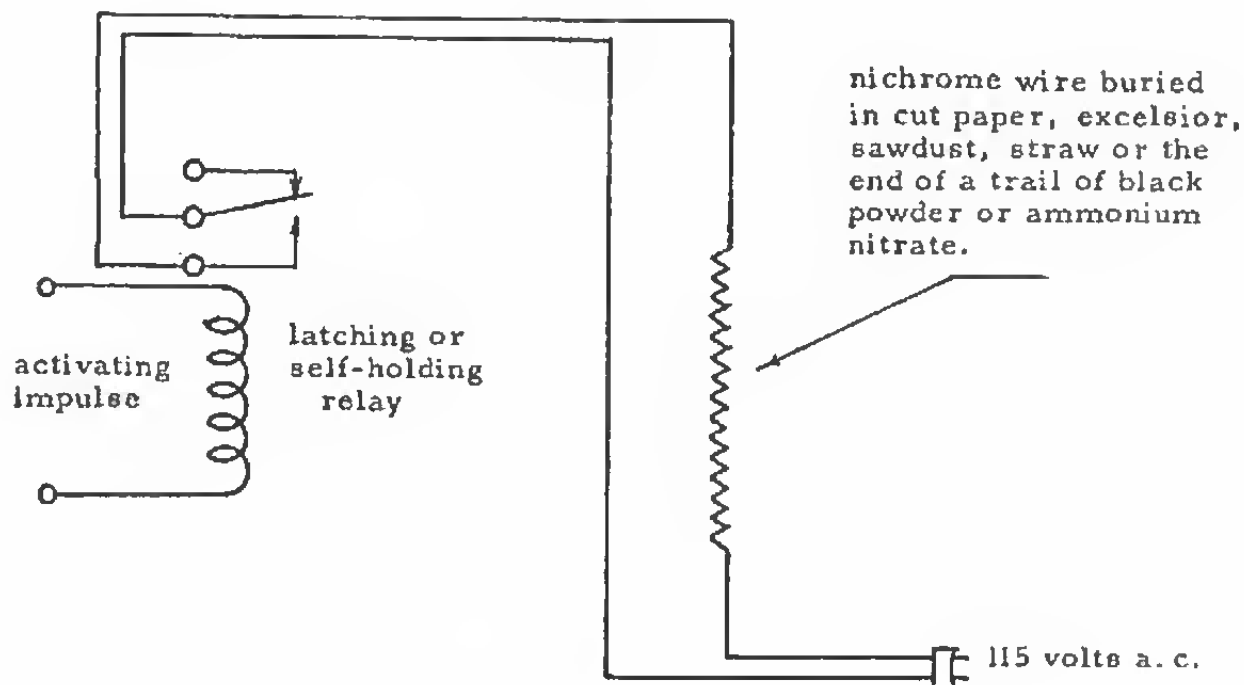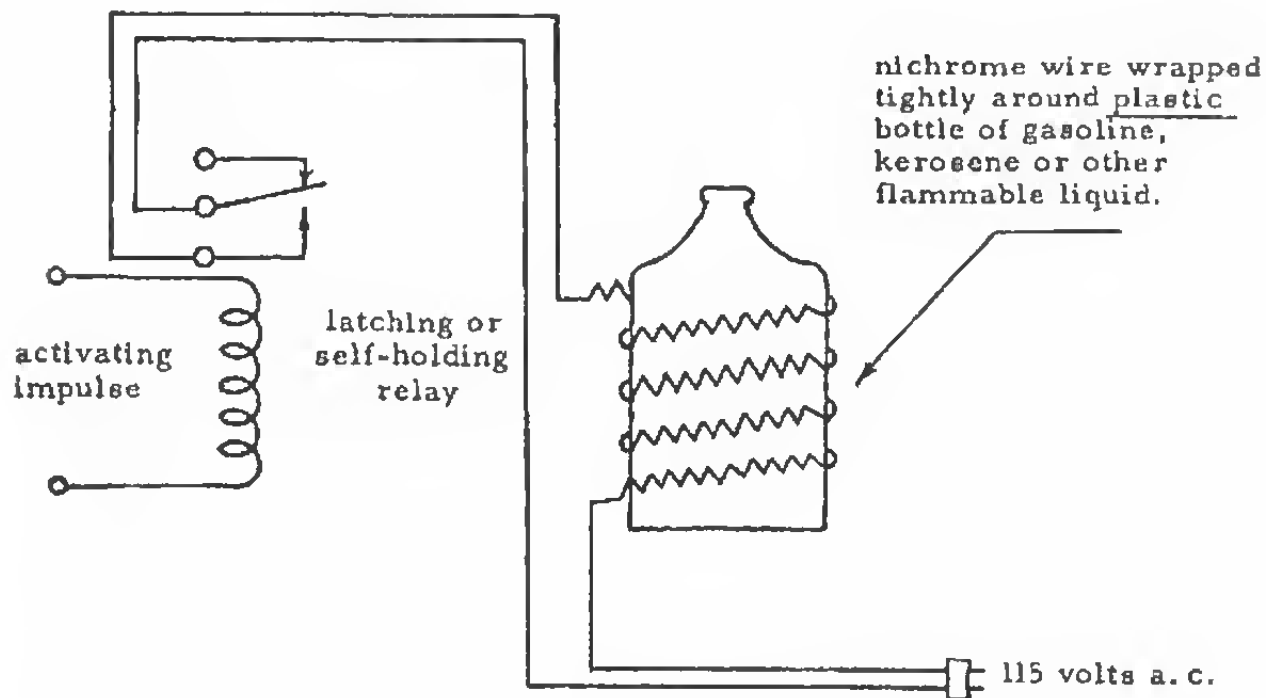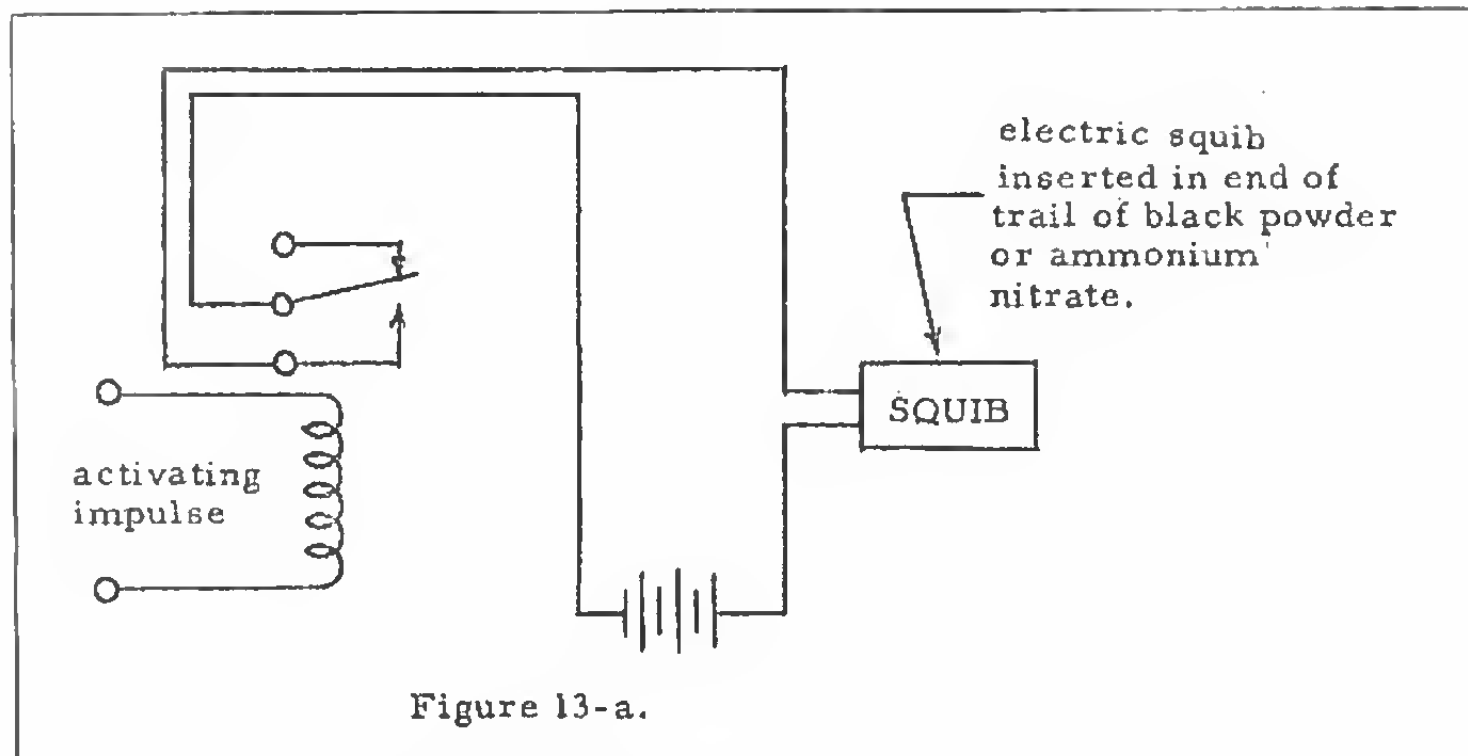
Figure 12-b.

obdurate material will be found at the fire
site.

The electric squib is attractive as an initia-
tor, and offers the additional dividend of be-

electric squib
inserted in end of
trail of black powder
or ammonium
nitrate.

activating
impulse

SQUIB

Figure 13-a.

ing operable in an uninhabited building; i.e., one without a supply of electricity. A small dry-type battery will readily fire either an electric squib or an electric blasting cap with only a momentary passage of current. (Fig. 13-a, 13-b)

The method diagrammed in figure 13-a is "sure-fire." When the relay closes, a surge of electrical current is sent through the ignition charge within the squib, and the intense flame

several electric squibs placed
in widely separated positions
in a room doused with flammable
liquid and/or filled with explosive
vapor.

activating
impulse

SQUIB   SQUIB   SQUIB   SQUIB

Figure 13-b.

electric blasting
cap inserted in
dynamite, blasting
gelatin or nitro-carbo-
nitrate.

electric
blasting cap

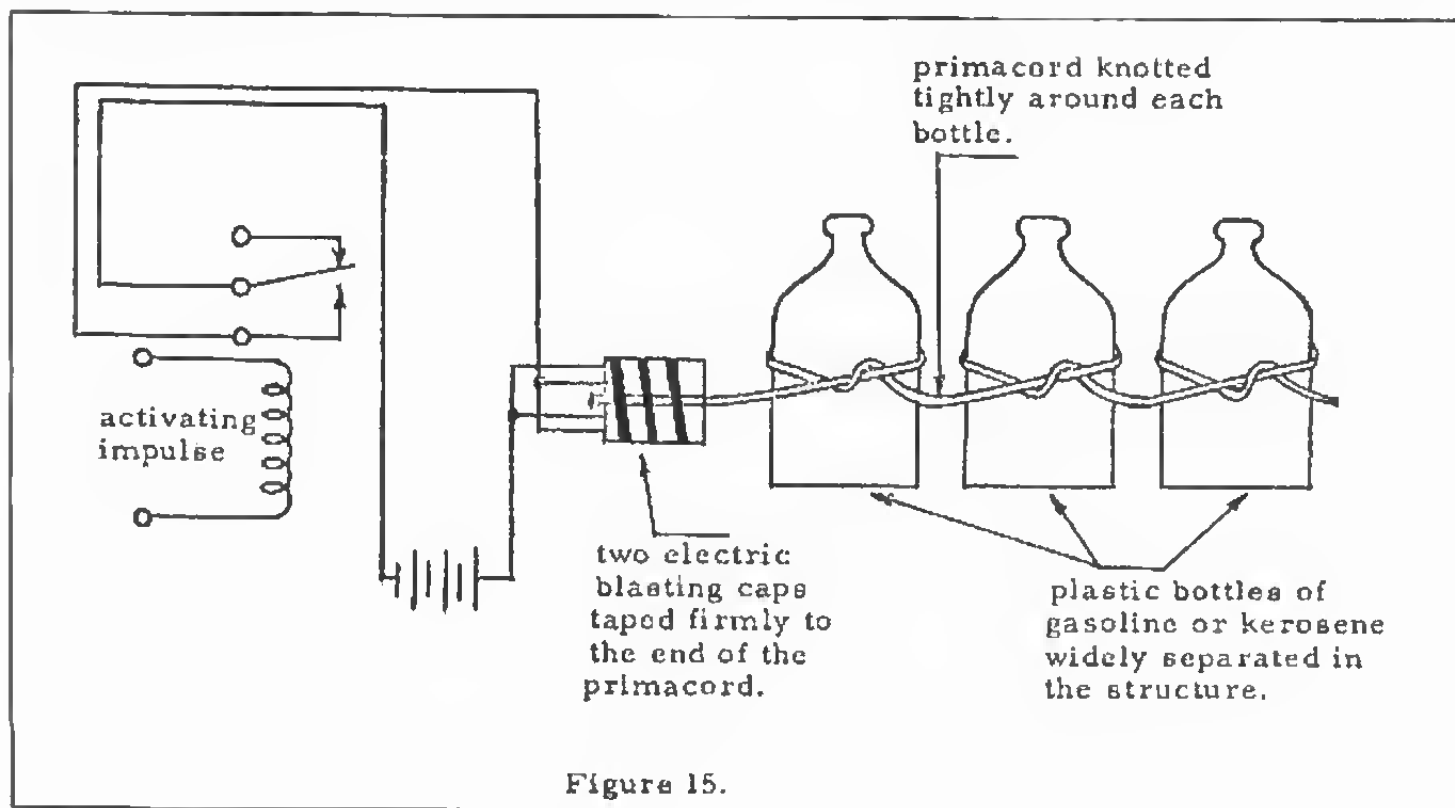activating
impulse
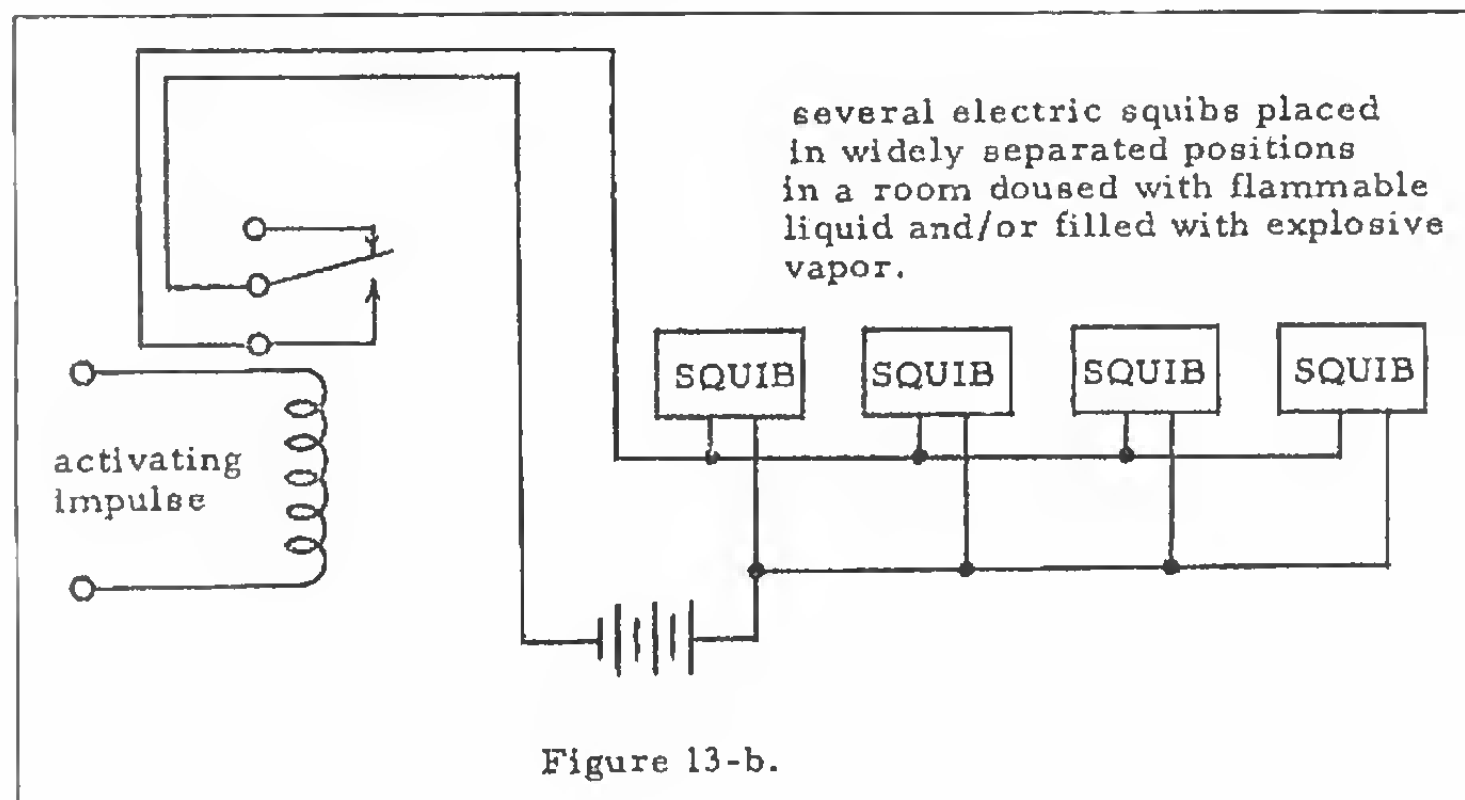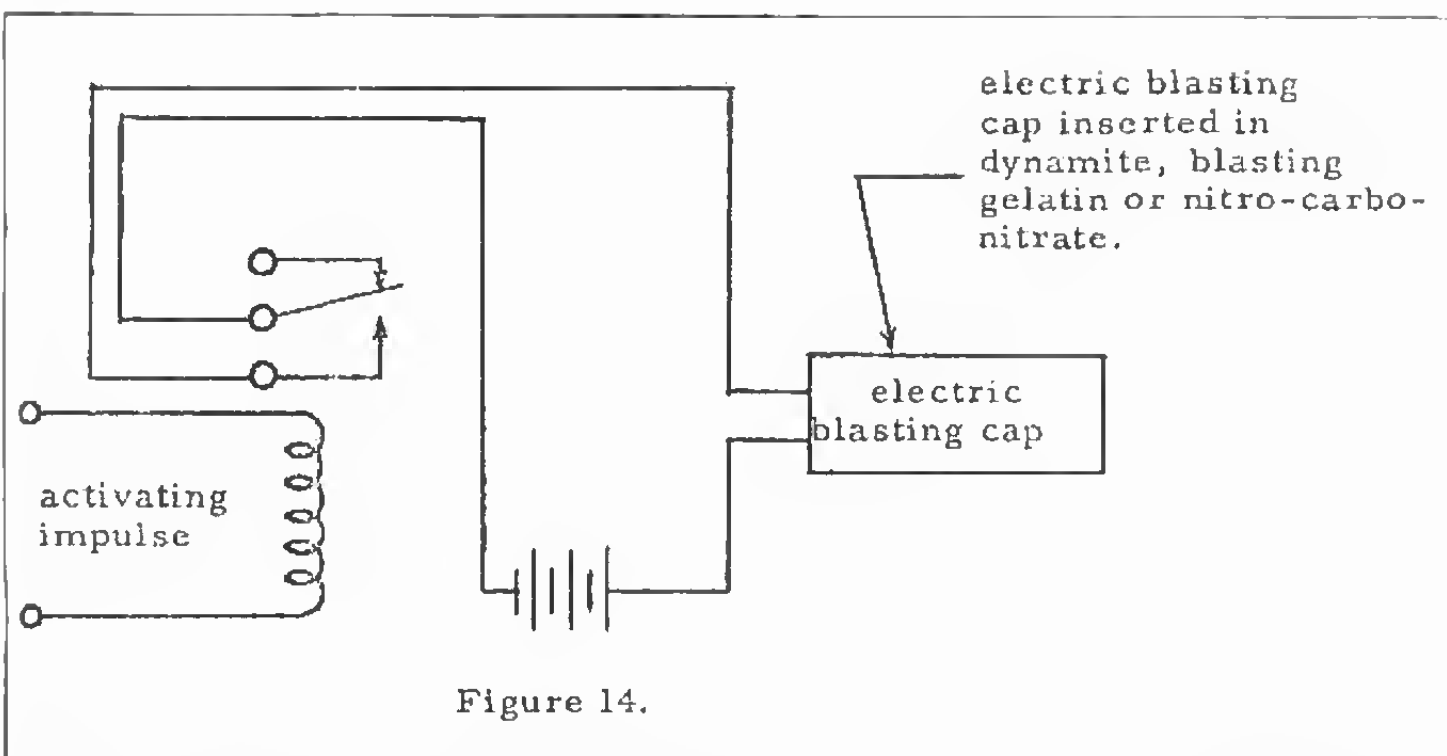
Figure 14.

issuing therefrom will, with certainty, cause initiation of the flammable substance.

The circuit shown in figure 13-b will work well, but has intrinsic unreliable aspects. As set forth earlier, liquids that evolve explosive vapors, as well as most potentially explosive products normally found in gaseous form, possess certain limitations with regard to the amount of vapor present in a given volume of air. A one-time-only flame, such as the squib

primacord knotted
tightly around each
bottle.

activating
impulse

two electric
blasting caps
taped firmly to
the end of the
primacord.

plastic bottles of
gasoline or kerosene
widely separated in
the structure.

Figure 15.

spark gap in room
filled with explosive
concentration of
gasoline vapor, kerosene
vapor, natural.gas,
butane or
propane.

Model "T"
spark
coil

activating
impulse

latching
or self-
holding
relay

storage
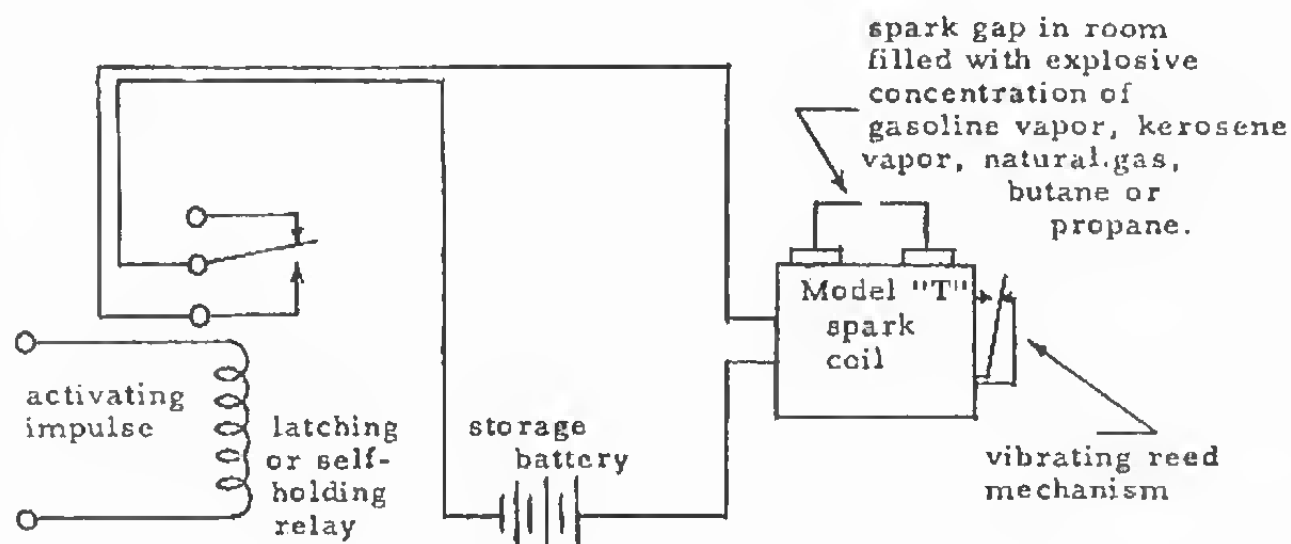battery

vibrating reed
mechanism

Figure 16.

produces, just might occur at a moment when the vapor concentration is beneath or above the explosive limits of the particular material used.

Electric blasting caps may be fired in exactly the same manner. (Fig. 14)

A momentary electrical current is introduc-ed into the cap, and detonation follows at once. The shock wave set up by the violent decomposition of the cap is more than enough to cause sympathetic detonation in most high explosives.

Primacord proves a valuable accessory device in a circuit embodying features from se-

horn gap placed
in room containing
an explosive
concentration of
vapor.

activating
impulse

latching or
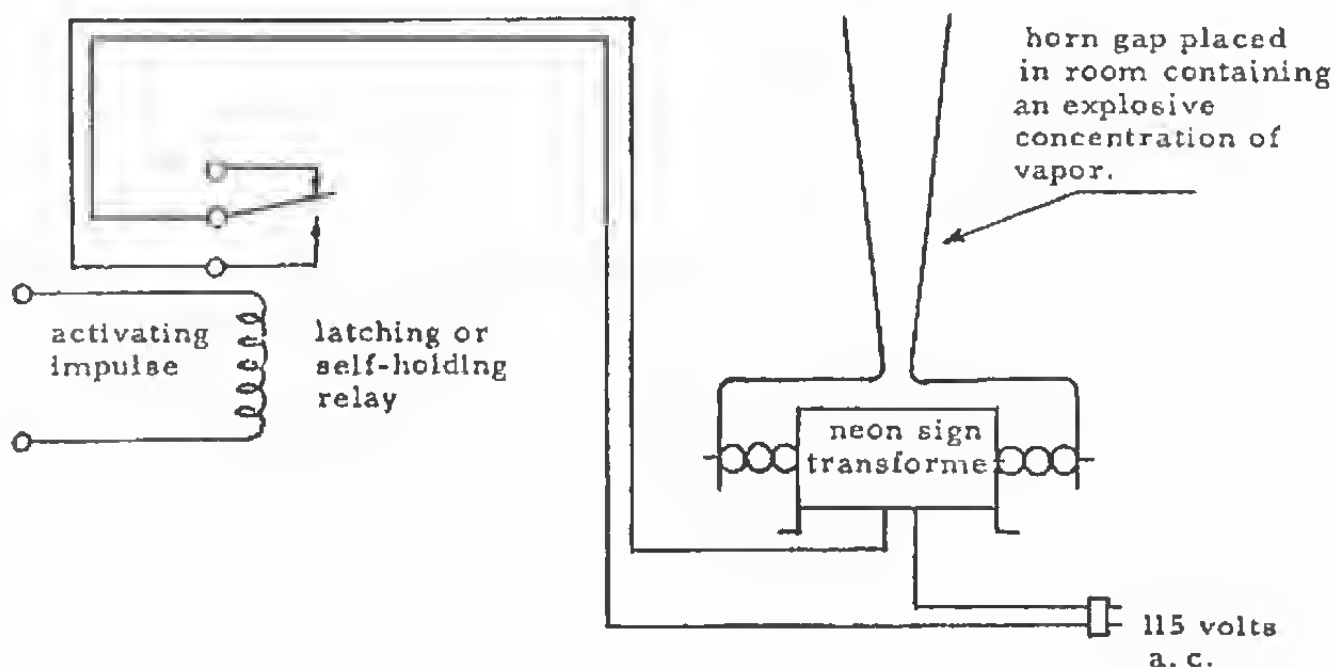self-holding
relay

neon sign
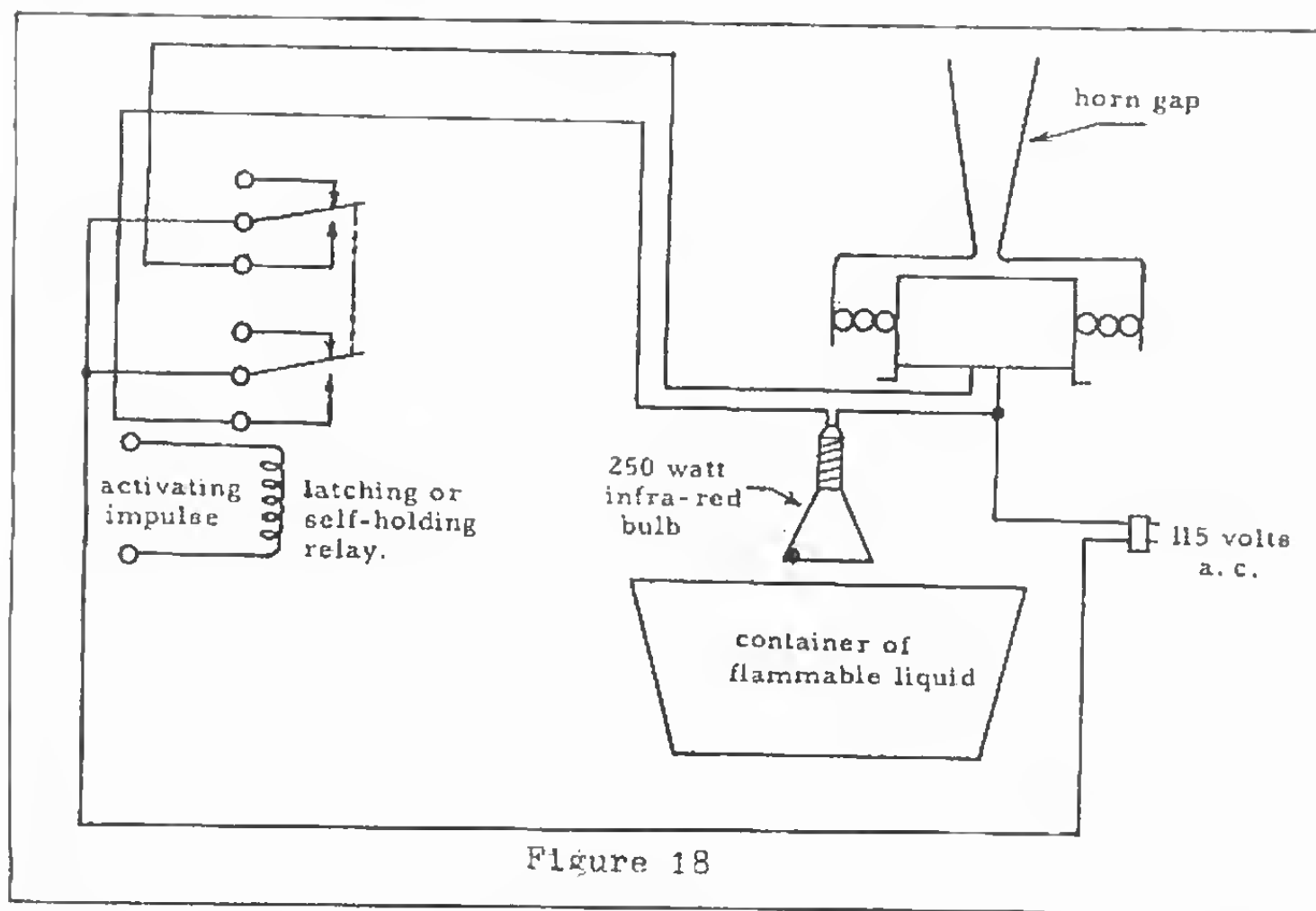transforme

115 volts
a. c.

Figure 17.

Figure 18

veral other configurations. (Fig. 15) This layout will cause rapid and wide-spread destruction. Actuation of the relay sends a momentary pulse of electricity to the blasting caps, detonating them. The primacord, having a core of highly explosive PETN, detonates from the ensuing shock wave, the detonation taking place at about 21,000 feet per second. A sudden high heat level accompanies the explosion. The bottles of gasoline are ripped apart by the explosion, the fluid is ignited by the heat, and the flaming material is hurled over a wide area. A large structure can be implanted with many such devices, and all may be fired simultaneously.
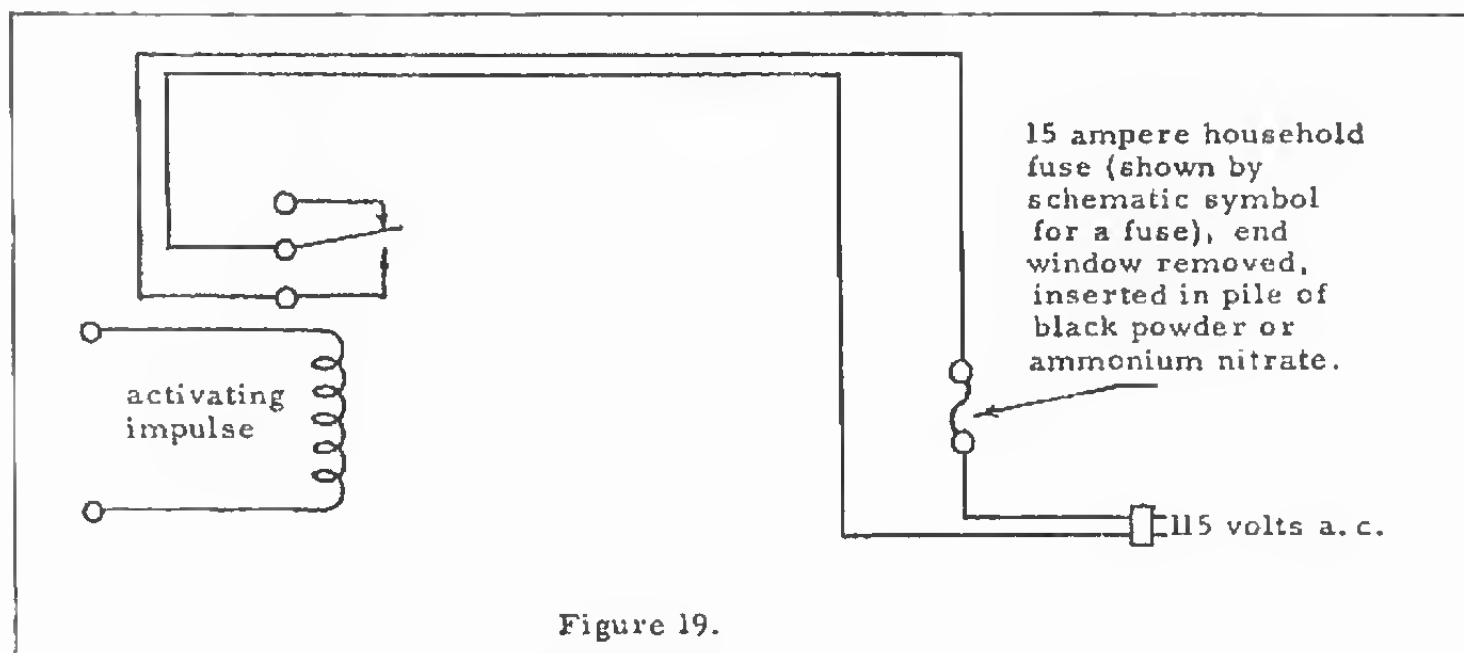
In all probability, the only thing left in the debris would be parts of the relay and fragments of plastic from the bottles.

The electric spark, because it can be arrang-

ed to recur over a long period of time, is a much more reliable way to touch off explosive vapors. Even though the volume of vapor present is not within the explosive limits of the substance used, the spark can continue until a suitable concentration of vapor has built up, or until an excess concentration has dwindled to the proper ratio. Figure 16 shows the connection of a model "T" spark coil. A six volt wet storage battery should be used if the spark is to continue for any length of time.

The action is exactly the same as that shown in figure 16, except that a longer and more effective spark is furnished by the horn gap.

Electric light bulbs may be utilized following the schematic hookup in figure 10. The main stipulation in their successful employment is that they must be well insulated from

15 ampere household
fuse (shown by
schematic symbol
for a fuse), end
window removed,
inserted in pile of
black powder or
ammonium nitrate.

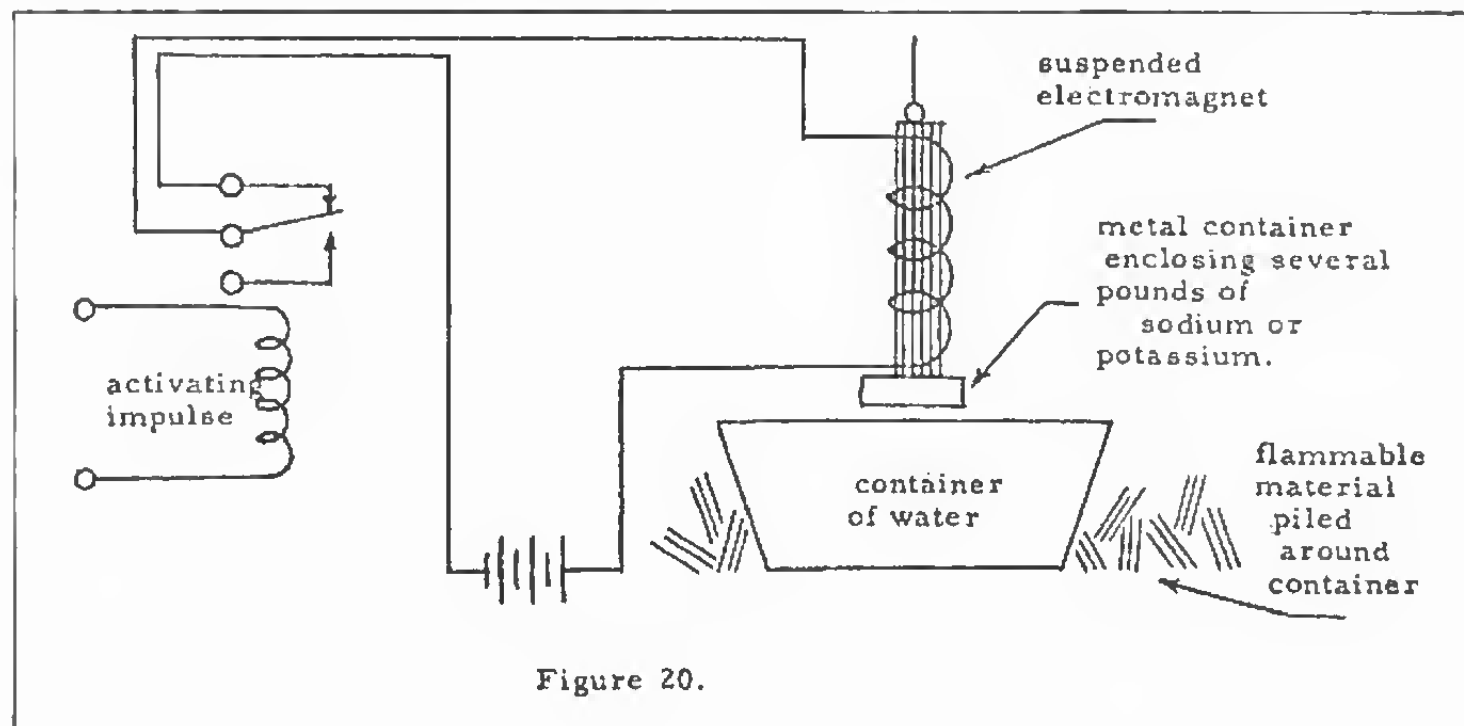activating
impulse

115 volts a.c.

Figure 19.

the ambient air by the flammable material, accumulation of heat being the object.

If attempt is made to initiate an arson with a spark gap and one of the less volatile flammable liquids, the addition of a multiple contact relay and an infra-red heat bulb will increase the chances for satisfactory performance. (Fig. 18)

This would be a useful technique in conjunction with the heavier fuel oils. Number four oil, for example, has a minimum flash point of 130 degrees Fahrenheit. If the heat of the oil is brought up above this critical temperature, vapors are evolved that will be almost as dangerous as gasoline vapor. Best of all, the correct concentration of vapor in the surrounding air is assured. Rapid evolution of vapor does not begin to take place until the

suspended
electromagnet

metal container
enclosing several
pounds of
sodium or
potassium.

activating
impulse

container
of water

flammable
material
piled
around
container

Figure 20.

heat from the bulb strikes the oil. When it does begin, the concentration increases until the amount passes through the lower explosive limits. At this point, ignition occurs. A short element of time delay after the initial triggering is an extra dividend furnished by this method.

After an incident involving spark gaps, parts of the units may be found in the fire residue. These units, incorporating induction coils in one type and a huge step-up factor in the other, contain dense masses of small wire wound on solid metal cores. In addition, the windings are often "potted"; that is, impregnated or dipped in transformer varnish or tar-like substance to prevent the intrusion of moisture during normal operation. The smell of burning or recently burned impregnating material is characteristic and, once encountered, will be easily recognized. The neon transformers are usually supplied in heavy steel cases. Portions of the heat lamps may survive. Often having an outer covering of pyrex glass, they can withstand temperatures that would completely obliterate an ordinary bulb.

The efficacy of the household fuse as an initiator has already been set forth in another section. A fuse of the older variety, one having a mica end window, is desired. Its firing circuit is uncomplicated. (Fig. 19)

Note that it is not necessary to use a latching or self-holding relay. A single impulse to the relay's activating coil will cause disruption of the fusible link and, accompanying the incident, an intense flash of flame. If black powder is employed, the fuse should not be buried too deeply.

The photographic flash bulb may be fired by the same circuit, but a flashlight battery will furnish enough power to do the job.

It is unusual to think of the electromagnet per se in terms of arson initiation but nevertheless, it will work. (Fig. 20)

Notice the difference in the connection of the relay contacts. Here, the activating impulse *opens* the top pair of contacts, breaks the circuit energizing the electromagnet, and the container of chemical falls into the water.

electric blasting cap
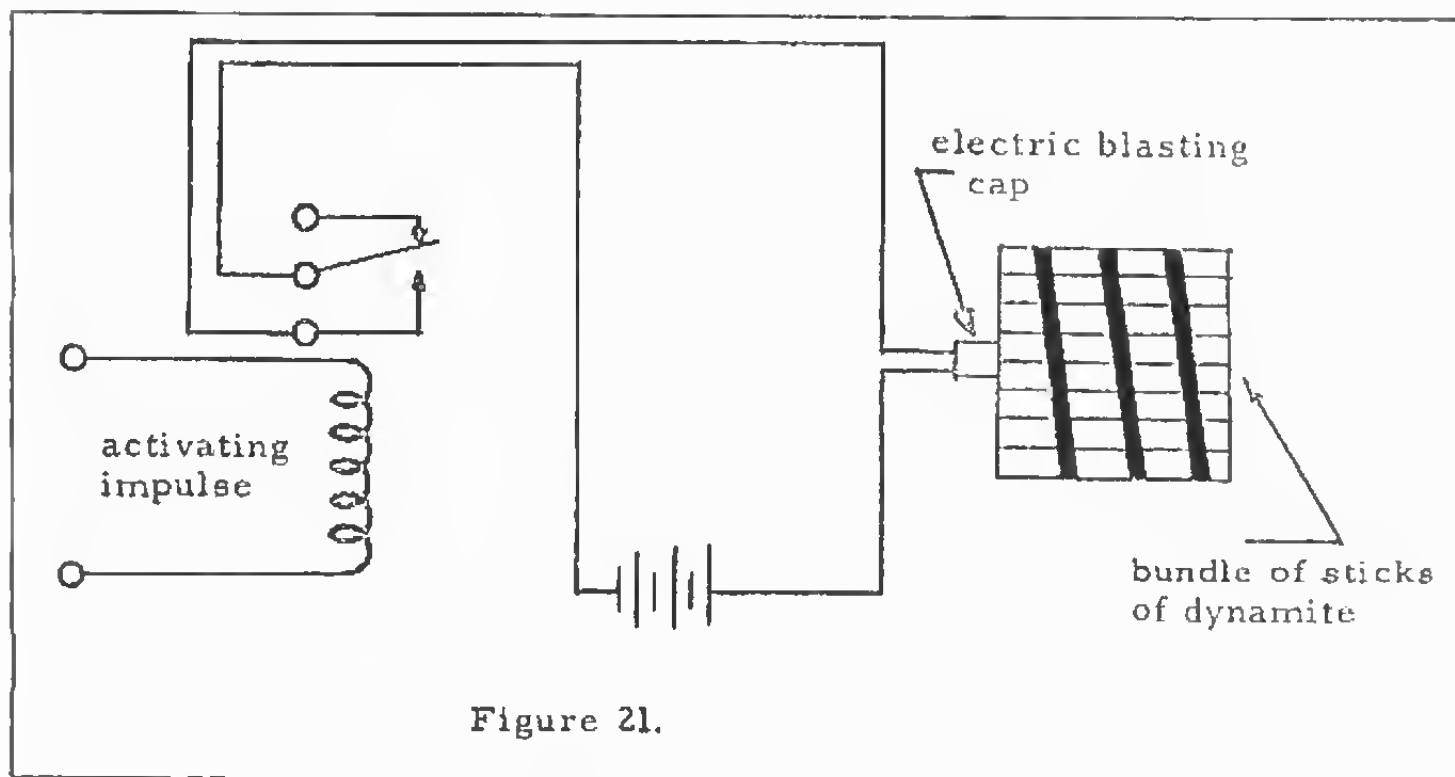
activating impulse

bundle of sticks of dynamite

Figure 21.

The resulting violent decomposition ignites the flammable material piled near the water container.

A battery is shown as the magnet's power supply, but certain arrangements can be made to operate it from an alternating current source. If a battery is used, care should be taken that the unit does not become depleted and drop the container prematurely.

All of the circuits described heretofore are uncomplicated and straightforward. These, however, may be expanded into truly diabolical mechanisms; mechanisms that can grow to a huge scale. Take the simple detonation of an explosive charge as a case in point. (Fig. 21)

A triggering pulse of electricity is sent to the activating coil of the relay, the relay closes, a pulse of electricity from the battery is fed to the blasting cap, the cap detonates, and sympathetic detonation takes place in the

electric blasting cap

activating impulse
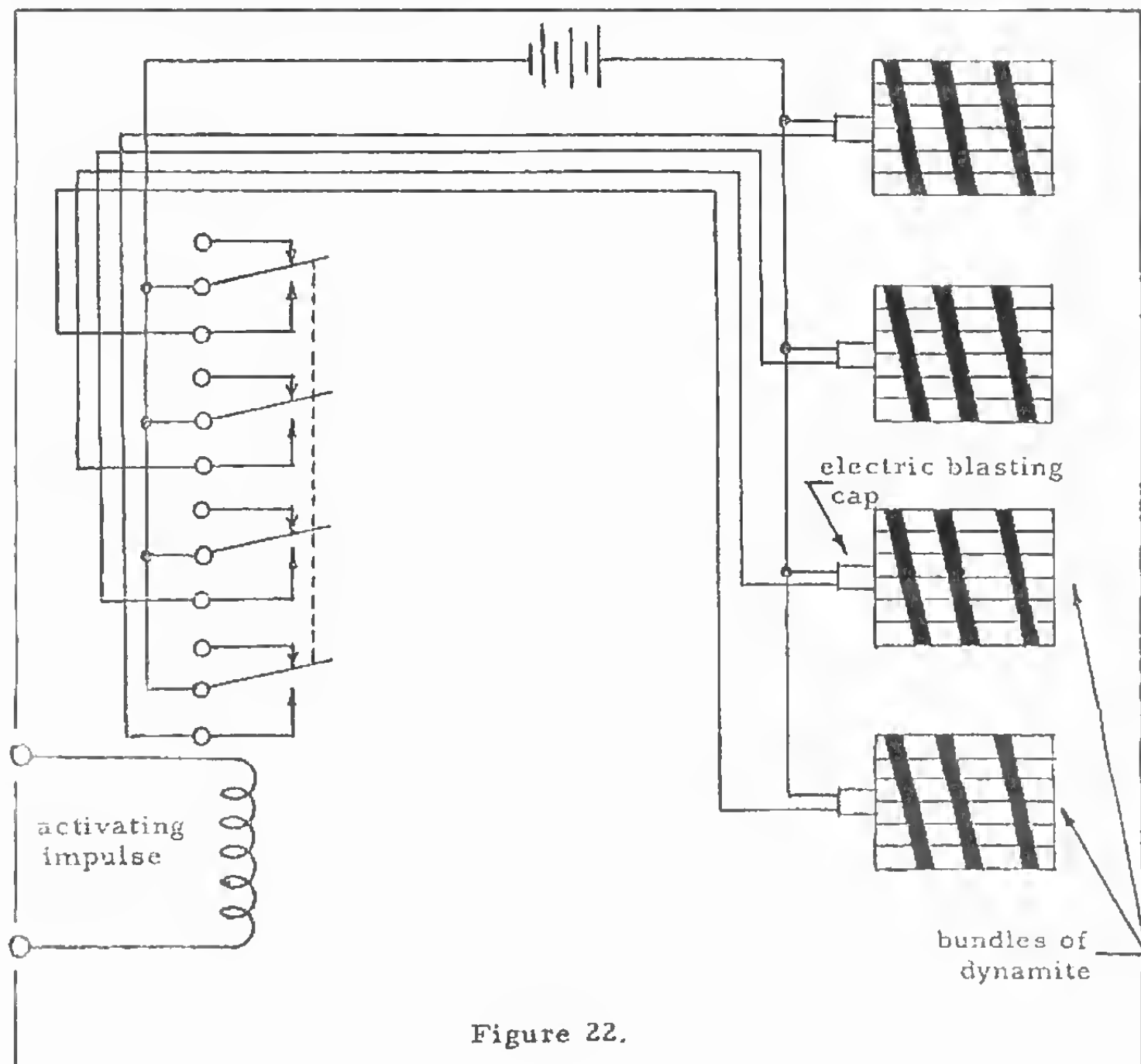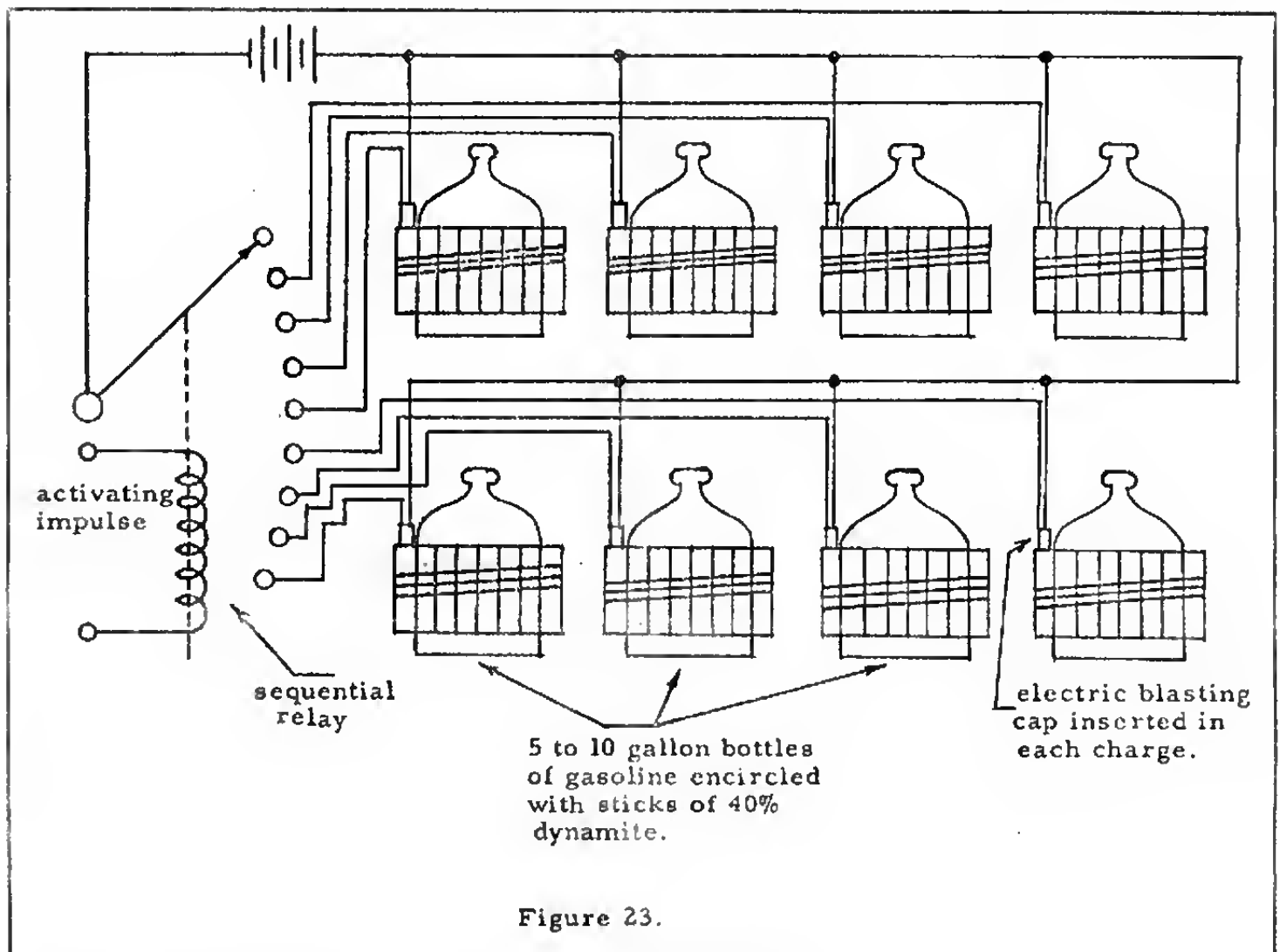
bundles of dynamite

Figure 22.

dynamite.

This will cause great damage in a small structure or under favorable environmental conditions, in a larger structure. But suppose conditions are *not* favorable; suppose the structure slated for demolition is *much* larger. Then this circuit, with the use of a different relay, more wire and more explosives, may be expanded into this. (Fig. 22)

Action is the same as the circuit in figure 21, with the exception that each pair of relay contacts fires an individual explosive charge upon closing. Taking care to provide enough power to compensate for extra-long wire length, the charges may be widely separated in a building. Nor is the number of charges li-

mited to the four shown. Each firing circuit may be subdivided by parallel connections and the number of contact pairs in the relay may be increased, so that the individual "plants" may number in the hundreds if need be.

Perhaps the arsonist wishes to be "cute"; perhaps he or she has developed a special dislike for law enforcement authorities or for members of the fire services; perhaps he just likes a good show for his money. A little extra time and effort and a sequential relay will give him one. (Fig. 23)

The explosive charges are placed at vantage points that will permit the blasts to inflict a maximum amount of structural damage. The

activating impulse

sequential relay

5 to 10 gallon bottles of gasoline encircled with sticks of 40% dynamite.

electric blasting cap inserted in each charge.

Figure 23.

electric
blasting cap
in each
charge

timer
2 min.
delay

timer
4 min.
delay

timer
6 min.
delay

timer
8 min.
delay

115 volts a. c.

5 to 10 gallon
bottles of
gasoline
girdled with
sticks of 40%
dynamite.

activating
impulse

master relay

latching or
self-holding
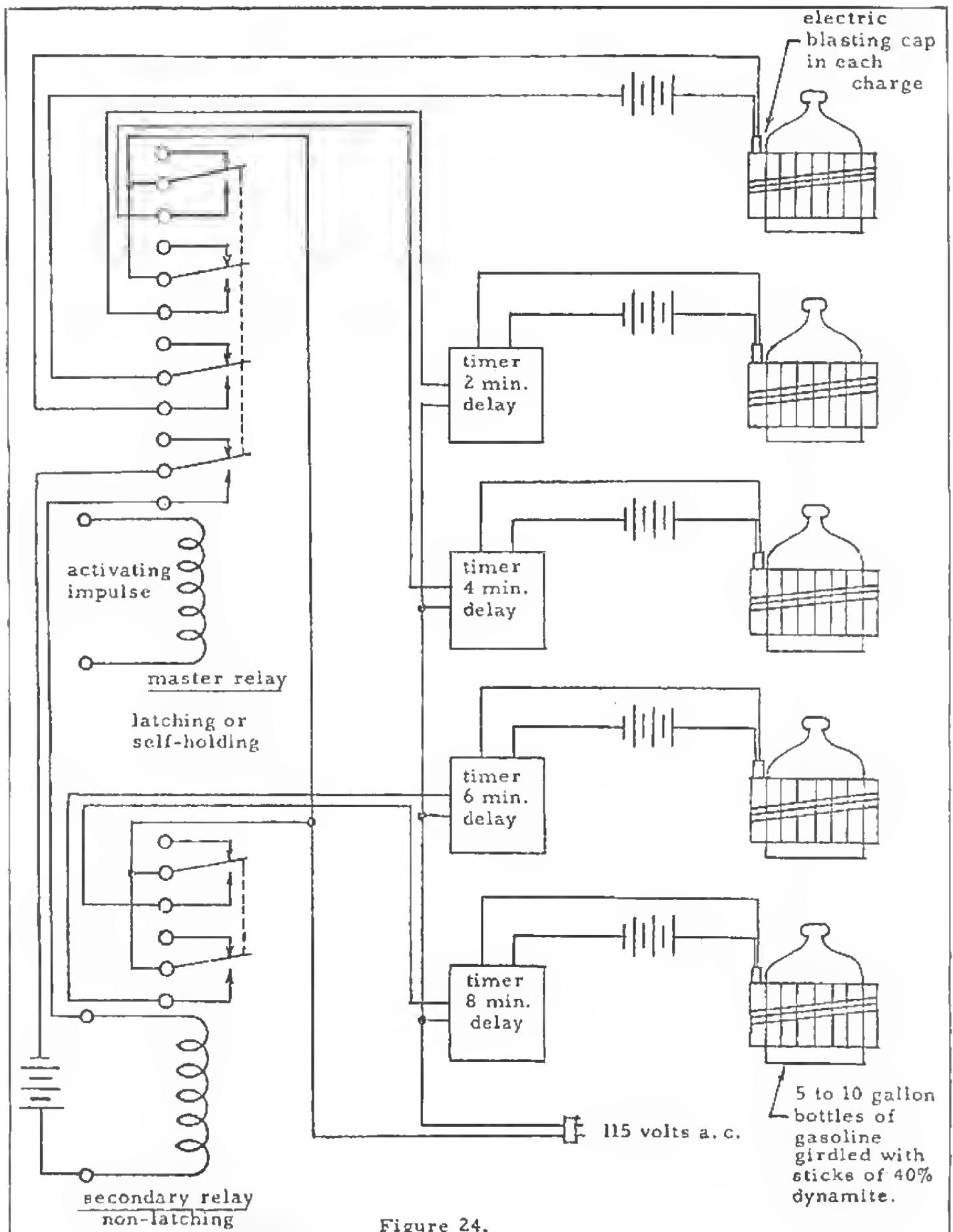
secondary relay
non-latching

Figure 24.

explosions also break the bottles, ignite the gasoline, and hurl it throughout the building. Each time an incoming electrical impulse enters the actuating coil of the relay, the stepping mechanism moves one notch, firing the explosive charge connected to it. The charges may be spread over a large area. If the arsonist occupies a commanding position where he can watch the progress of the fire, he can detonate the explosive units at his leisure. He may choose to wait until the fire services have begun their battle before firing all of them.

But perhaps he is squeamish; perhaps he would rather be far removed from the scene of the incident. If so, he can use this kind of circuit to accomplish the same result with thoroughly predictable accuracy. (Fig. 24)

The circuitry exhibits some unusual features. Notice that two relays are used, and that they are connected in "cascade"; that is, the closing of one relay effects the closing of another. This broadens the potential number of circuits that can be operated electrically to an unlimited amount. Only one pair of contacts in a multiple contact relay need be util-

ized in energizing a succeeding relay.

The employment of electrically powered timers is quite different from the basic circuits heretofore described. These provide an extremely essential function in this hookup.

A single actuating impulse arrives at the master relay. All contacts snap closed and remain closed, the action closing the secondary relay. At the instant the contacts operate, the number one explosive/gasoline "plant" is set off. At the same time, all of the electrically operated timers begin to run. Each of these is set in increments of two minutes from the time of the initial impulse. Every two minutes, one of the timers runs out its course, and another charge is detonated. Since the fire services almost always arrive on the scene in well under five minutes, they should be actively at work fighting the fire before the detonation of the final charges. Placement of charges should not be such as to disrupt the flow of electricity to the timers.

With electronics, the size and the complexity of the "plant" are unlimited.

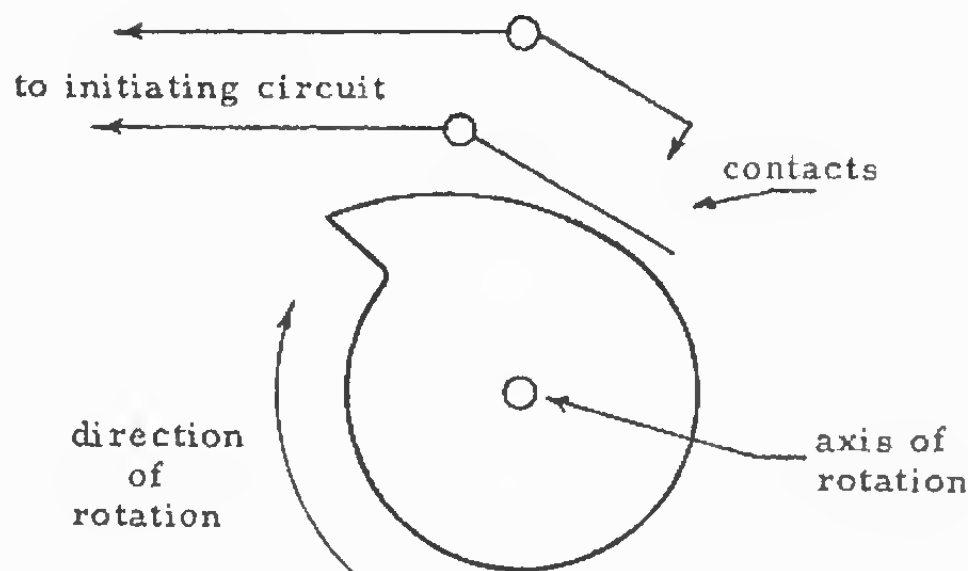One link in the chain of electronic arson

Figure 25.

remains unforged. One question remains un-answered. *How can the activating relay be opened or closed by remote control?* It is here that the full impact of electronics is felt, and the remaining portion of this manual will be devoted to some of the answers to that question. Shakespeare had a word for it: "All the rest is prologue."

VI. TIMERS:

Timers occupy a unique position among the host of electronic triggering mechanisms extant. Operating by means of principles mechanical as well as electrical in nature they form, as it were, the bridge or the connecting link between conventional arson and electronic arson. Such devices have been welcomed by criminals over the past years becuase of the facility with which they may be applied, because of the ease in which they may be obtained, and because of their efficiency and reliability.

In earlier applications, most of these units were strictly mechanical, consisting of a spring-driven clockwork movement which, after a predetermined period of time, closed a spring-driven clockwork movement which, after a predetermined period of time, closed a switch. Often, similar contrivances were improvised from quite ordinary alarm clocks.

(illustration about
one-half actual size)

Figure 26.

The mechanical action is elementary.(Fig. 25) A cam or some other animating protrusion is arranged to rotate on a clockwork-driven shaft. The shaft revolves until the point of maximum projection arrives under the blade of the switch. Pressure from the protuberance closes the contacts, and the initiator is triggered.

Although sometimes very crude in their makeup, these gadgets have always been popular with the do-it-yourself-bombers, and many successful crimes are on record that had mechanical timers at their hearts.

Spring-driven timers possessed one great advantage. Since they were not reliant on a supply of electricity, they would work anywhere. They could be (and have been) sent through the mails while operating. Despite this good feature, one unfavorable salient point predominated. Because their springs had to be wound on occasion, they were primarily short term devices; i.e., they usually were unable to run for more than a day or two.

Most of the modern timers are electrically driven. Spring-driven timers still exist but are, for the most part, confined to uses requiring short intervals of one hour or less. Spring-driven timers are frequently used in the photographic darkroom and, while they are handily available in many places, are not practical in the commission of arson because of their short time-measuring capabilities.

In the electrically driven timer, the customary means of propulsion is a small synchronous motor. (Fig. 26) These are habitually furnished sealed in cases of thin brass or other metal. They are found in all sorts of timing devices as well as in commonplace electric clocks. Their ultimate action is the same as that described in figure 25. The motor moves a clockwork gear train, and some kind of cam closes a pair of contacts at a pre-set moment. At times, these units are incorporated in regu-

lar home appliances that utilize a timing function. Sometimes they are self-contained. Commonly they are rather simple in their particular service. Often they can perform a complex series of operations.

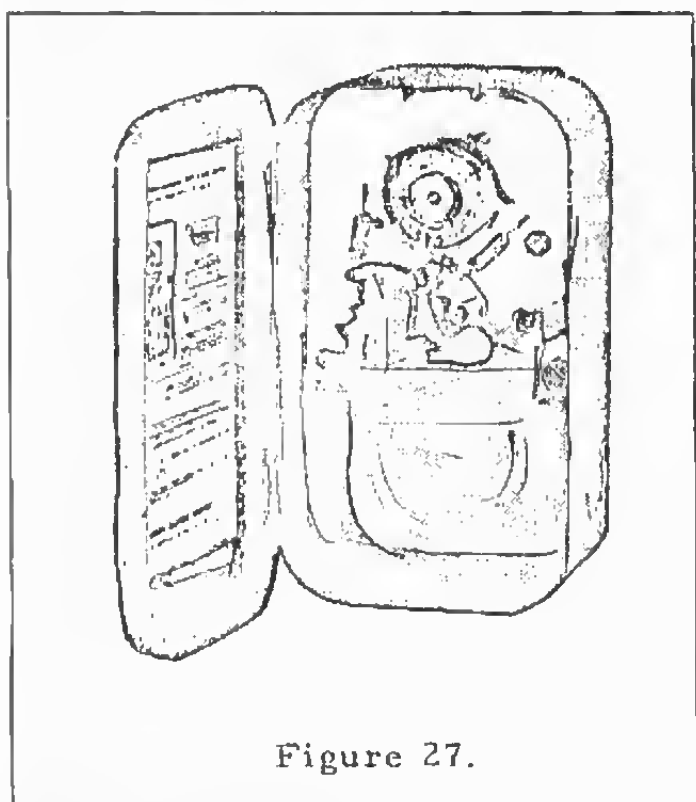Figure 27 shows a self-contained timer of a

Figure 27.

type that will be quickly recognized by most people.

This species has been of inestimable aid to the farmer and to the industrial user for a long period of years. In the above illustration,
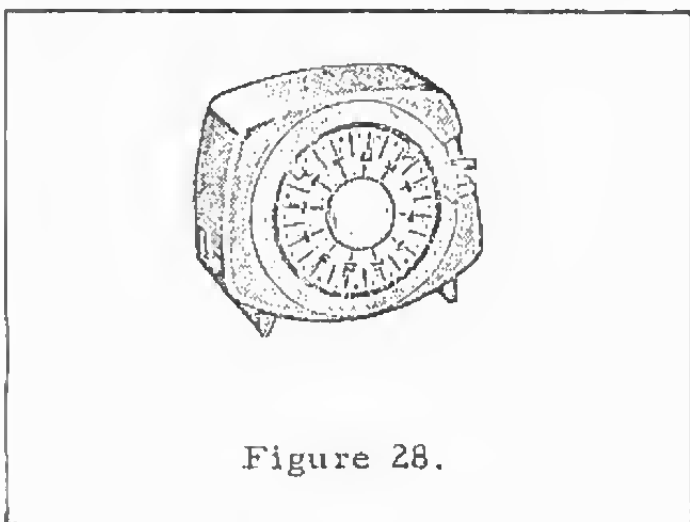
a little above the center, the timing calibrations can be seen marking off the hours and the subdivisions thereof. The drive motor and its associated gear train is located behind the panel on which the dial is mounted. Note the heaviness of the case; it is ordinarily made of steel.

In operation, the motor slowly revolves the calibrated dial. "Trippers" or small metal fingers are attached to the dial at the time marking desired. When the dial reaches this point,

the contacts close. This kind of timer can be purchased almost anywhere at a cost of about eight dollars. With this mechanism, as with all other timers, the contacts, together with a battery or an alternating current supply, may be used to operate the activating relay or the contacts may, in certain instances, be used *as* the activating relay.

The foregoing unit is somewhat limited in that its dial makes one complete revolution in a twenty-four hour span. However, for an additional five dollars or so, a similar unit can be had that is calibrated in increments of seven days as well as in hourly sections. This feature widens considerably the timer's possible scope of usage in electronic arson.

More decorative and compact variations of this basic generic unit are on the market. (Fig. 28)
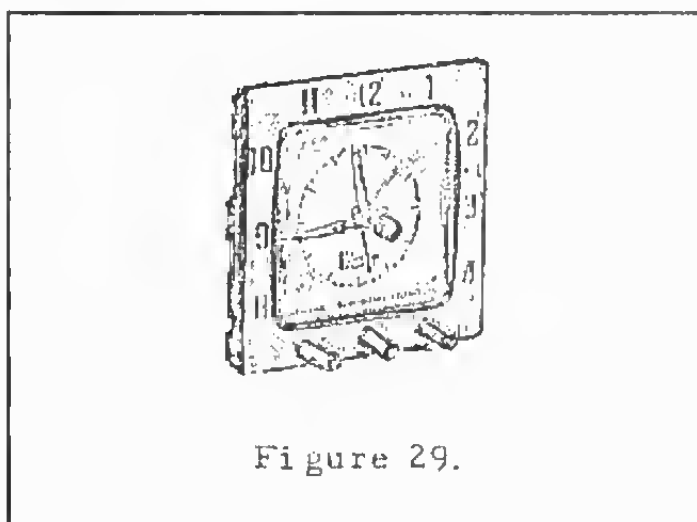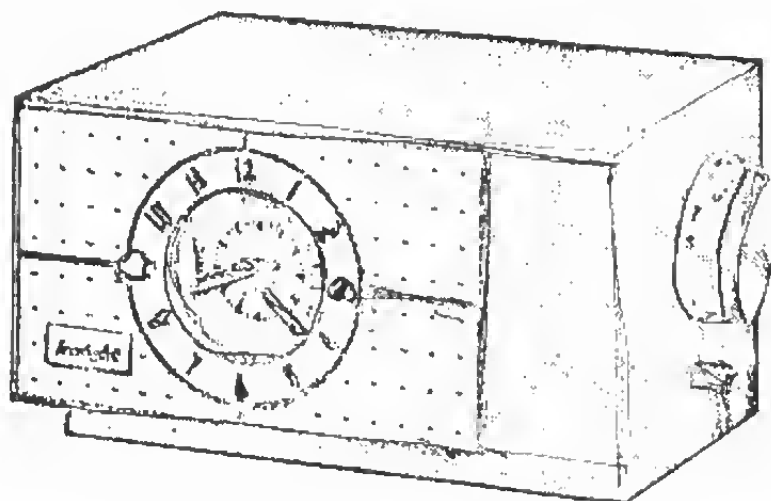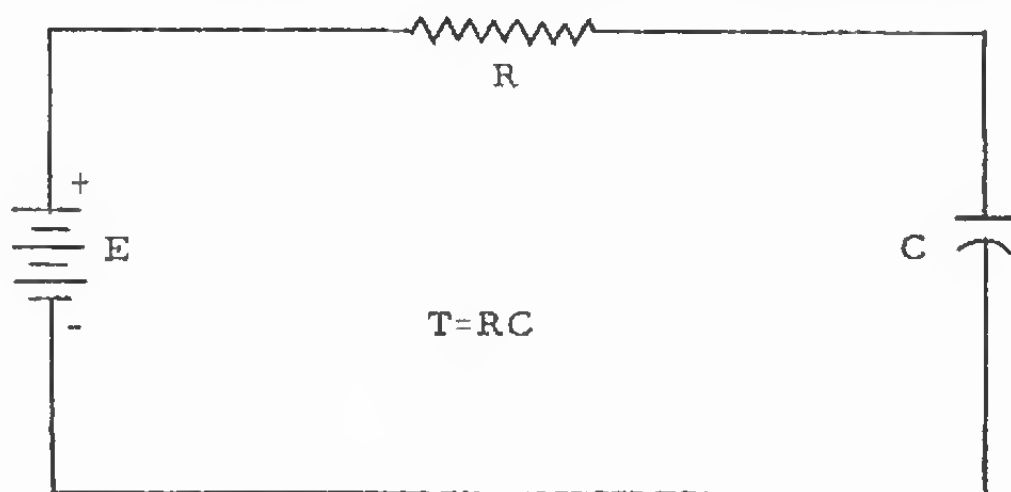

Figure 28.

Figure 29.

Figure 30.

The steel-clad devices were built for permanent, long-term operation; the smaller, plastic-enclosed articles were intended for incidental use within the immediate living area of a home. The operation of both is the same, nevertheless, and the plastic unit, while not so impressive, is by no means ineffective.

Even smaller, uncased versions of this type of timer are built into many home appliances of recent design. Elaborate devices of this nature are incorporated in most automatic washers. These quite often possess the ability to initiate a sequential series of events, and could be readily subverted to the arsonist's use were

$$T = RC$$

T is the time in seconds
R is the resistance in ohms
C is the capacitance in farads

Figure 31.

it not for two qualificatory facts; they must be started manually, and they run their entire course within one-half hour to forty-five minutes.

Comparable timers are contained in most of the modern electric ovens. (Fig. 29) In reality, these consist of nothing more than an electric clock set to run constantly, and a trigger mechanism operated by the clock that may be set to function at a given time.

An even more familiar mode of utilization of this kind of timer is its inclusion within a so-called "clock-radio." (Fig. 30) The terminology is somewhat misleading. The timer is merely a unit of a variety quite ordinary in every sense of the word, except that it is contained in the same case with the radio. Internal circuitry is such that the clock/timer may be set to energize the radio at a given instant. In almost all cases, an auxiliary outlet is comprehended in the unit for the purpose of actuating some external device at the same moment.

All prior considerations regarding timers have dealt with their electro-mechanical characteristics, and this may have given rise to the impression that mechanical linkages are essential to chronological mensuration. This is definitely not true, and it is here that we find the bridge into pure arson by electronics.

The operation of exclusively electronic timers is founded upon two fundamental principals. When a resistance and a capacitance are connected in series in a circuit, and a voltage is impressed across that circuit as in figure 31, the hookup is said to possess a time-constant.

In unadorned phraseology, this is the time required for capacitor "C" to charge through resistor "R" to the applied voltage "E." As may be expected, the time constant of a circuit will vary with the size of the resistor and the size of the capacitor. This relationship is expressed in the formula $T = RC$.

The second precept concerns the gas-filled tube. While the great majority of vacuum tubes have, as their name implies, been highly evacuated, some are deliberately filled with rather exotic gases at low pressure. If a voltage is introduced across the tube's internal electrodes as in figure 32, an interesting phenomena takes place.

If the voltage is increased to a certain critical value, the gas within the tube ionizes, and a flow of current between the electrodes is set up. It may be observed that each tube so filled with gas exhibits a tendency for the gas to ionize and thereafter to conduct when an exact exciting voltage is reached peculiar to the particular tube in use. Prior to the ionized

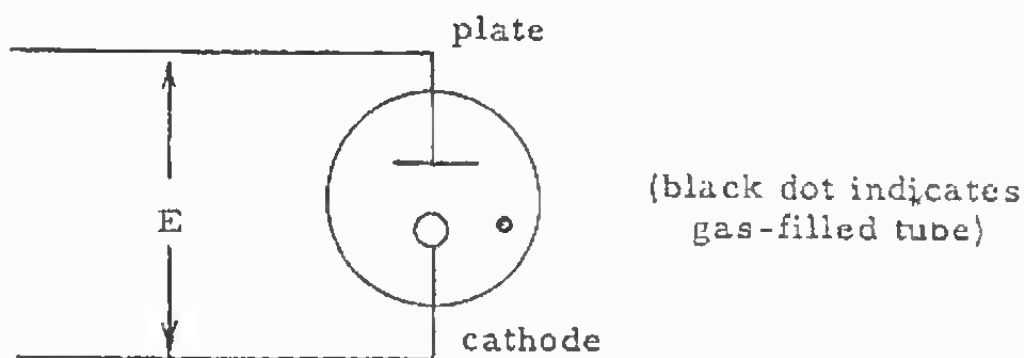plate

E

(black dot indicates
gas-filled tube)

cathode

Figure 32.

state, conduction of electricity through the tube does not occur.

Like some short-term mechanical timers, the electronic timer, as normally found in industry, also covers a brief time span. Devices of this general makeup are used in governing the length of welding processes, radio-frequency heating procedures, and countless other manufacturing practices.

Figure 33 illustrates an electronic timer that negates this limitation. In analysis, the circuit is really two separate resistance-capaci-

tance circuits functioning by virtue of a common power supply. The flow of charging voltage into the second circuit is intermittently controlled by the repeated cycling of the first.

The detailed action is as follows. The switch is thrown, and capacitor C2 begins to accumulate a charge through resistors R3 and R4. When C2 charges to the ionizing potential of the first gas-filled tube V1, the tube suddenly conducts, a current flows through the actuating coil of relay 1, and the relay's con-

Figure 33.
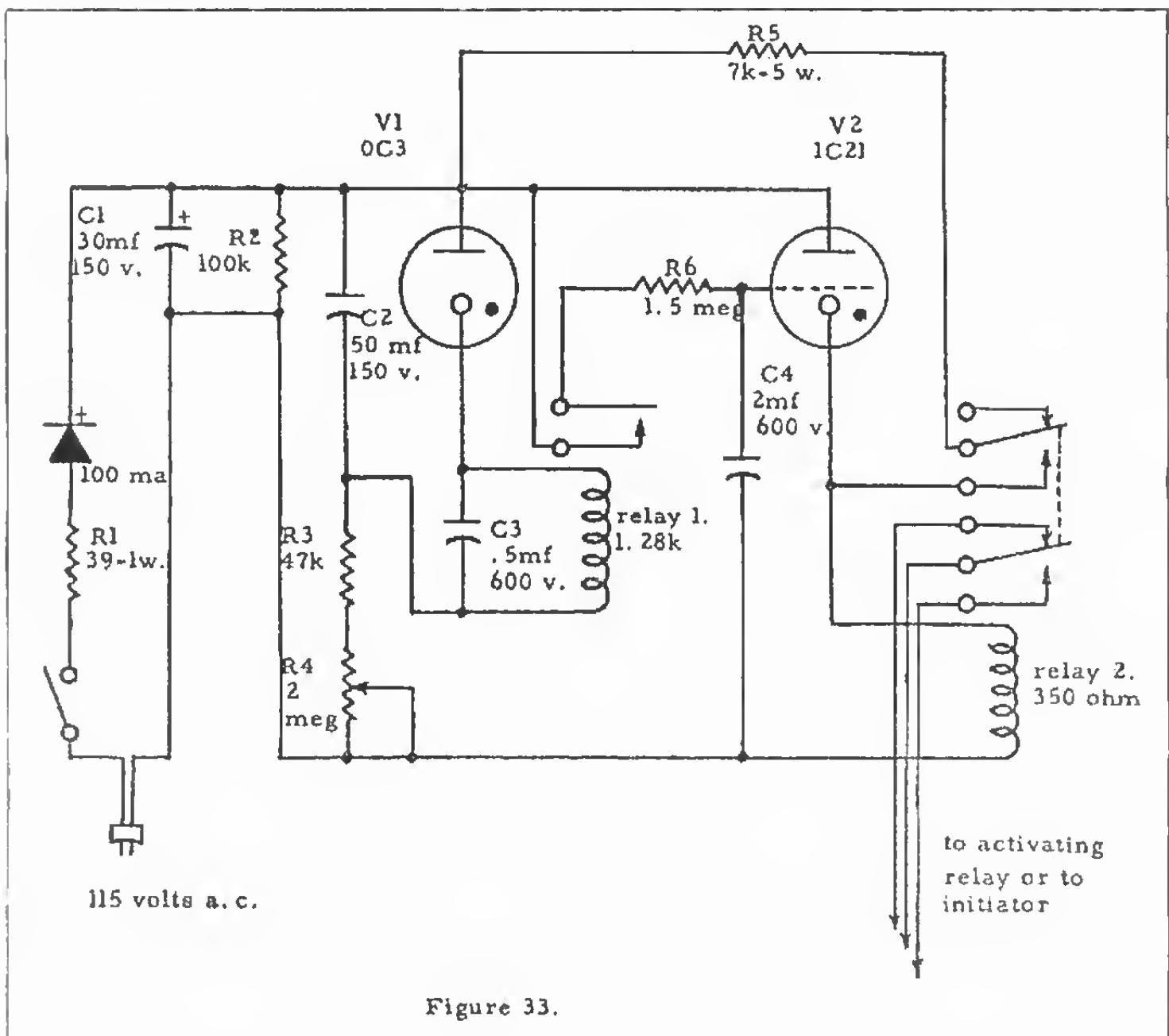
tacts close. This causes capacitor C4 to begin to take on a charge through resistor R6. Meanwhile, the charge gathered by C2 is rapidly leaking away through the coil of relay 1, and through the tube V1. As soon as the charge falls below the voltage necessary to maintain ionization of the gas in V1, conduction through the tube is cut off. As a result, the contacts of relay 1 open, the charging of C4 is interrupted, and C2 begins to accumulate another charge. The cycle repeats itself again and again until C4 has achieved a charge sufficient to cause ionization in the second gas-filled tube V2. When this state is realized, relay 2 closes. Two of the accompanying contacts operate either the activating relay of the incendiary or explosive device or the device itself, and the other contacts supply the coil of relay 2 with a self-holding voltage.

The key to this unit that makes it so applicable to arson is the fact that the resistance-capacitance circuit made up of R6 and C4 displays a large time-constant, and by the fact that its charging voltage is supplied in brief increments. About 15 to 16 hours must pass before C4 can gather a charge great enough to operate relay 2. As R6 is enlarged in value, the time-constant increases until several days may be required for the relay to close.

The investigator may be assured that the use of timers in the initiation of arson will be most difficult to pin down. Because of their ubiquitous nature, and because they have every right to be present in the home, in the factory, or in practically any conceivable situation, it will be a burdensome task to prove that they had been placed at the suspected crime site for a nefarious purpose.

When timers are used in the commission of arson, the principal suspect may well be expected to be at some distance from the location of the event. He will probably be able to offer substantial proof that he could not possibly have been present at the point at which the crime originated at the time specified. He may have been in the company of reputable and highly respected citizens.

It is almost mandatory that the timer be used in connection with some electrical device, either a regular home appliance or a device especially contrived. Since timers that encompass periods of twenty-four hours or less are definitely in the majority, their use may be justifiably suspected if such time relationships are evident, and particularly if opportunity exists to initiate a crime through the application of some electrical apparatus. This peculiar time element should not be adopted as a general rule-of-thumb however, because the longer-term interval timers do exist and may be encountered.

If the use of a timer is suspected, look for evidences of the driving motor. Being encased in metal and possessing a driving coil wound on a metal armature, it may survive even though it would probably be distorted. Unless the resulting fire is unusually intense, the unit shown in figure 27 will certainly have the remains of the steel case as part of the fire residue. Keep in mind that it would not be a common practice to make use of such a timer in the habitable areas of a building.

Where clock-radios (figure 30) are employed, a variety of significant debris may be discovered. The bulk of all radio enclosures are manufactured either from wood or plastics and these would, therefore, disintegrate in a fire of any magnitude. Most of these radios are built on a rather heavy steel or aluminum chassis, and various components are often riveted to this metal base. A normal superheterodyne receiver will probably include a double-section variable capacitor having a rather heavy mounting. Carbon resistors or certain metal-encased capacitors may come through the fire reasonably intact. Parts of the clock

are likely to be found.

Some similar components may be left behind if a purely electronic timer is involved. In this instance, a metal chassis may not be used, since amateur builders and experimenters often "bread-board" their layouts; that is, they build them on the surface of an ordinary piece of wood in order to speed construction and to hold costs to a minimum. In this case, the wood might burn completely and this would be advantageous to the arsonist. Resistors and capacitors would also be used in this type of circuit, although they would not be as well protected as they would be in a regular commercial unit. Parts of the relays might be in evidence, and the toggle switch may be expected to retain most of its original characteristics.

The big problem with regard to timers, besides their initial detection, lies in establishing proof that they were placed at a certain location for the express purpose of committing a crime.

VII. PROXIMITY DEVICES:

The characteristic symbol for a vacuum tube was displayed in figure 5-c, and the gas-filled type of tube was briefly discussed in the preceding section, but nothing has been said concerning the fundamental principle upon which such devices operate.

The simplest kind of vacuum tube consists of two elements. (Fig. 34)
The cathode, or the negative electrode, is shown in the illustration as pin number one; the plate, or the positive electrode, is indicated by pin number two. If a certain voltage is connected from pin one to pin two, no current will flow between the electrodes because they are not physically connected, and because the tube envelope is highly evacuated (in contrast to the gas-filled tube mentioned in the last chapter wherein the gas can ionize
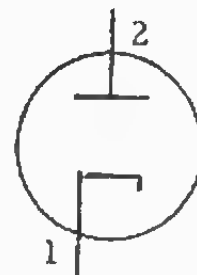

Figure 34.

at a given electrical potential). Should the cathode of the tube be heated to a given temperature, however, the phenomena of thermionic emission takes place. Electrons are given off from the surface of the cathode, and a current of electricity then flows between the cathode and the plate.

When this manifestation was first discovered, it was regarded as something of a laboratory curiosity, until it was learned that the tube had the ability to accomplish rectification; i.e., the changing of an alternating current to a direct current. Consequently, modern diode rectifiers are still in use in large quantity.

Eventually, an additional feature made possible our present-day system of electronics. This is based on the essential physical axiom that unlike electrical charges attract one another, and like electrical charges repel one another. A third electrode, the control grid, is inserted between and at close proximity to both the cathode and the plate. (Fig. 35) The grid, being a sievelike affair much like a piece of screen wire, is found to exert control over the current flowing in the plate circuit of the tube as would an electrical valve. In fact, the English still refer to vacuum tubes by the graphic term "valve." If the cathode of the tube be operated at a negative potential, if the plate of the tube be operated,
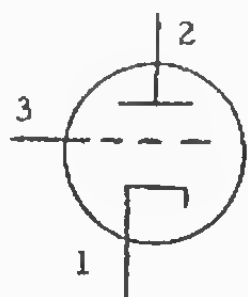
Figure 35.

at a positive potential, and if the grid be charged to a sufficient negative potential, then the electrons leaving the surface of the cathode will be repelled and will be prevented from reaching the plate. If, on the other hand, the grid is charged to a great enough positive potential with respect to the cathode, the flow of current between cathode and plate will be encouraged. Due to the construction of the tube, a tiny variation in the polarity of the charge on the grid can control a relatively large amount of current flowing between the cathode and the plate. The pattern of current flow in the plate circuit will be an enlarged copy of the current flow in the grid circuit. On this concept, electronic amplification by vacuum tube rests.

In reality, the operation of the vacuum tube is not quite so simple as it appears because of a number of limiting factors, but the basic principles by which they function may be put to work in the construction of proximity devices that are, in turn, very applicable to the initiation of electronic arson.

The term "proximity fuse" was well known during World War II., but this item was really a refinement of various mechanisms that had existed for years prior to that time. As the name implies, a proximity device performs its action when a person or a thing comes within

a predetermined distance from the unit's sensing apparatus. The person or the thing may move toward the sensor, or as was the situation with the proximity-detonated projectile, the sensor may be moved toward the activating object.

One of the earliest of these devices was built around an oscillator, this being nothing more than an electronic amplifier arranged in such a way that part of the energy from the plate circuit is fed back into the grid circuit. This acts as an electrical "flywheel," and produces a more or less self-sustaining waveform of a type and of a frequency determined by the associated hookup.Oscillators can be built so that they are extremely sensitive to outside influences, and the trigger mechanism shown in figure 36 illustrates this perfectly.
This particular oscillator is constructed so that it is sensitive to changes in the capacitance of its tuned circuit. A Hartley-type oscillator is fitted with a capacitance detecting antenna attached to its grid (V1). This sensor may be a length of wire or a small plate of thin metal fastened to a door or to a window in the structure being "set up." Variations in this capacitance to ground, as effected by a person moving to within two to three feet of the sensor, will have the effect of changing the time-constant of the RC network R1 and C1. This will alter the amplitude of the oscillation. A portion of the oscillating voltage across the tuned circuit is rectified by the diode V2, and the output is filtered to become the control voltage applied to the grid of the relay tube V3. In short, if someone gets near the antenna of this unit, the relay will operate.

If such a device were used as a trigger for a "plant," and if it were installed in a business establishment at a propitious time, the arsonist would have ample time to travel to some distance before the event took place. If a busi-

ness were closed for the weekend, initiation would probably not occur prematurely. With the resumption of regular activities at the start of the week however, someone would eventually come to a door or a window, and when they did, disaster! An interesting side-light to this method would be the undisputed fact that the arsonist would not know when the crime actually occurred.

It is not absolutely necessary that an oscillatory circuit be used to achieve this net effect. The wiring diagram in figure 37 shows a hookup whose action is similar to that of the capacitance operated relay, but yet functions by an entirely different agency.

The integral wiring in most buildings tends to radiate a rather strong electromagnetic field. This is not directly evident to the inhabitants, but is sometimes manifested in hum in a radio or by electrical disturbances in a nearby television or hi-fi set. It is also a known and easily demonstrable fact that the human body is quite an efficient receiving antenna. This may be illustrated by grasping the antenna connector of a radio set and noticing the increase in signal strength that results.

Our old friend the thyratron tube appears in this circuit. Arrangements are made through the resistance network attached to the control grid of the tube so that a negative charge of sufficient magnitude is normally present to prevent current flow between cathode and plate. When a human body approaches the sensing unit, in this case a thin metal plate, electromagnetic radiations from the wiring in the building are picked up by the body and impressed, in addition to the normal negative charge, on the grid of the tube. Since this radiated field is alternating by nature, the grid swings alternately from positive to negative. When the grid is made sufficiently positive by the close proximity of the human body, the tube achieves a state of conduction, current flows through the plate circuit of the tube and hence through the activating coil of the relay, and the relay operates. A variable resistor, R3, is provided so that the threshold at which the device oper-
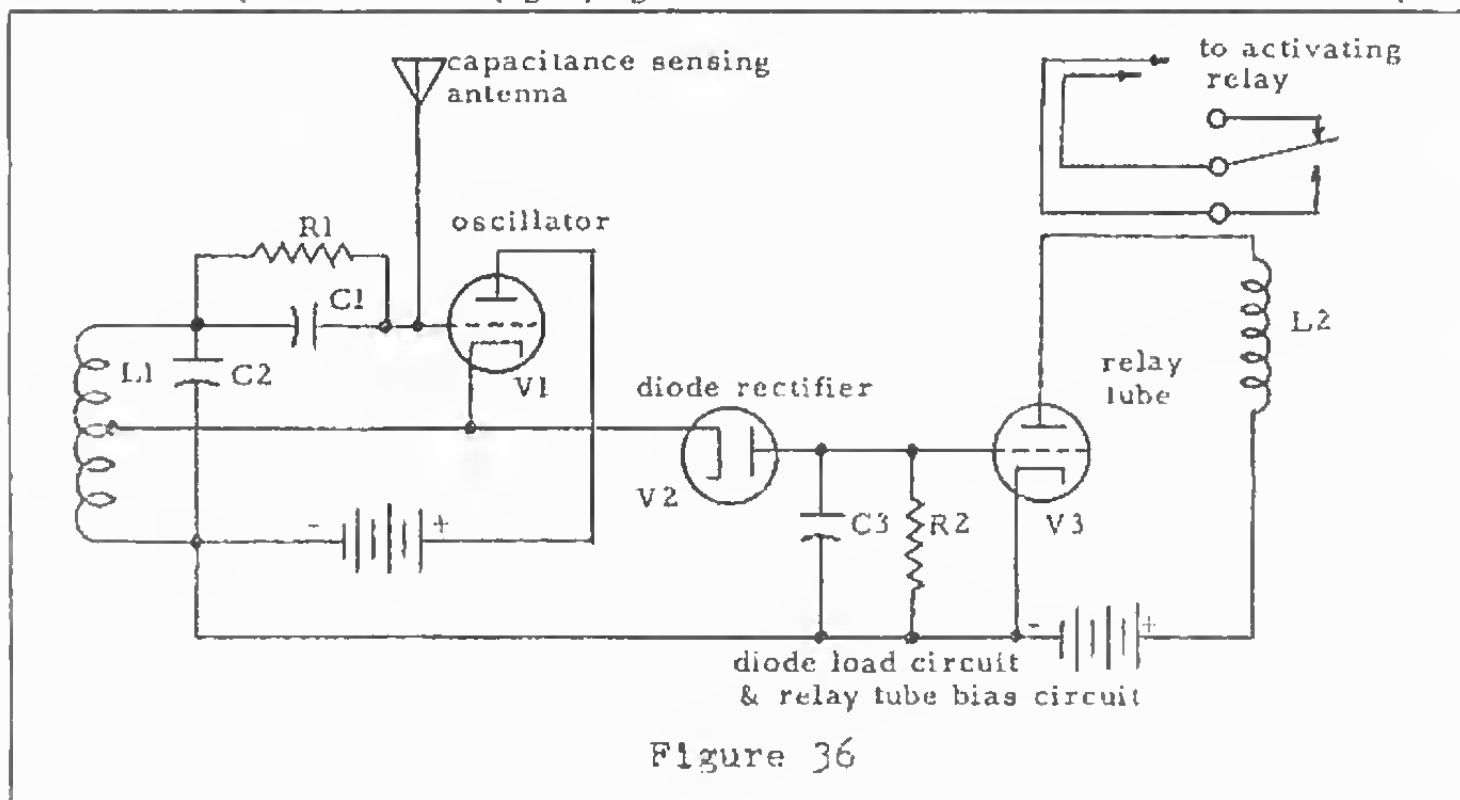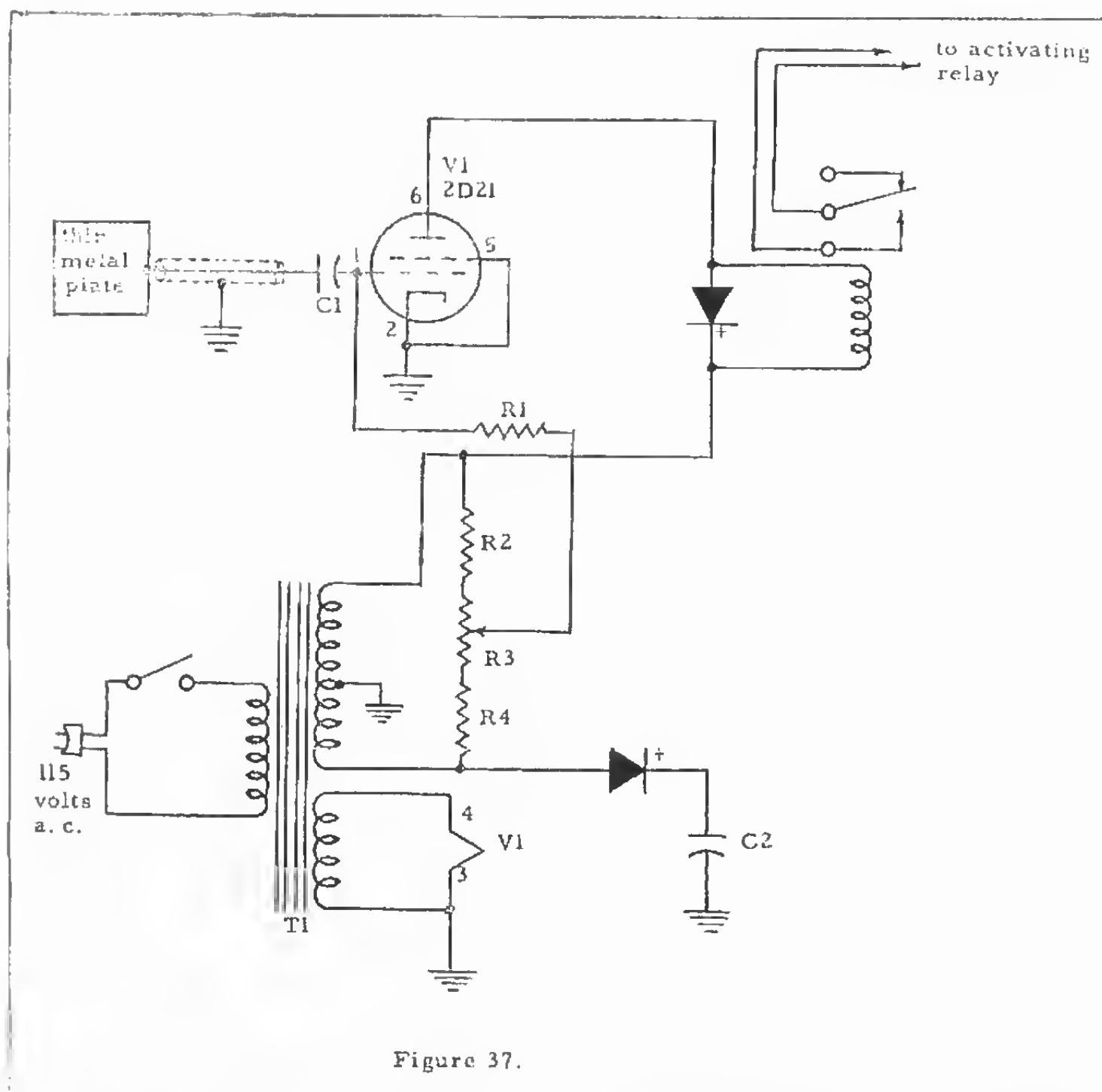

Figure 36

Figure 37.

ates may be readily altered.

If the cause of the fire or an explosion is not apparent, if the use of electronics in the initiation of the occurrence is suspected, and if the beginning of the fire or the detonation of an explosion coincides with the presence of a witness near a door or a window of the structure destroyed, look for a device of this nature.

Being electronic, the usual remains may be found in the debris; resistors, capacitors, relay parts, chassis, etc. In a unit operated by alternating current as shown in figure 37, the power transformer, T1, may be discernible. These components are often enclosed in steel cases, and usually have laminated cores of heavy steel. The core, if all the wiring is removed, will look something like this. (Fig. 38)

Vestiges of the sensing antennae may be left behind. These devices will work well even through a pane of glass of ordinary thickness, therefore, it is considered permissible practice to cement the metal plate or strips used for sensing directly to the inside of a glass window or door. Care should be exercised that such a sensor is not confused with a legitimate burglar alarm that often makes use of foil strips on the inside of a door or window in providing its needed protection. Thin wire sensing antennae are sometimes stapled to the surface of the door or window's framework.

VIII. PHOTOELECTRIC DEVICES:

Changes in light intensity provide a ready means of triggering a fire or an explosion, and may be considered from two diametrically opposed viewpoints. Associated circuitry can be so contrived that the photoelectric system will function by virtue of the sudden or the gradual exclusion of light or, conversely, by the sudden or the gradual addition of light.

approximately actual size

Figure 39.
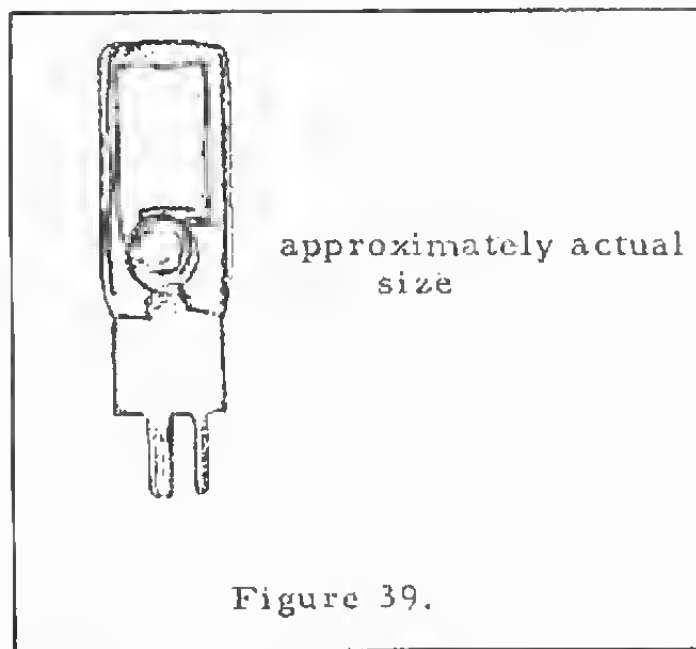
Units of this nature may also be set to operate at a specific light intensity.

All photoelectric components now in use fall within three broad classifications either as to their representative structure, or as to their mode of application:

    a. Photoemissive
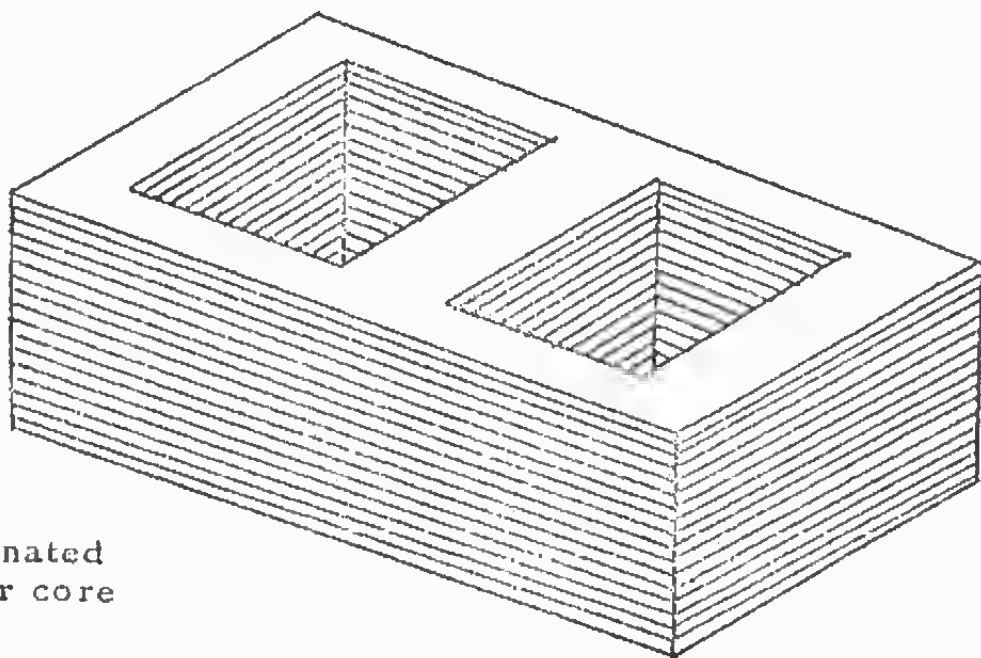   b. Photovoltaic

typical laminated transformer core

Figure 38.

c. Photoconductive

The oldest of these, and also the type in greatest use is the *photoemissive* cell. (Fig.39) In form, these instrumentalities are true vacuum tubes, although they are sometimes gasfilled in order to enhance the amount of emission. Like the conventional vacuum tube, they exhibit the capability of internal emission, but of a decidedly different character. A voltage impressed across the two elements of the tube will not cause a current of electricity to flow between the electrodes because of a lack of connection and because of the highly evacuated interior of the tube. In the ordinary vacuum tube, emission takes place by thermal initiation; in the phototube, emission is begun and sustained by ambient light impinging on the photocathode of the tube. The current flowing through the tube is a product of the total radiant flux falling upon the cathode and the luminous sensitivity of the cathode. The actual current derived from this action is proportional to the illumination in footcandles, the unit-candle or candlepower being an arbitrary standard of luminous intensity, and the foot-candle being the normal incident illumination produced by a one candlepower lamp at a distance of one foot.

Since the phototube displays an inherent high impedance, it is readily adaptable for coupling with the input of a vacuum tube amplifier as shown in figure 40. The 6F5 tube in the illustration is biased to "cut-off"(will not conduct) until light falling upon the photocathode of the 919 tube begins to alter this condition. When a sufficient amount of light is present, a current flows through the tube, and the grid of the 6F5 swings toward a positive polarity. When the grid becomes positive enough, the tube conducts, the 25A6 tube is
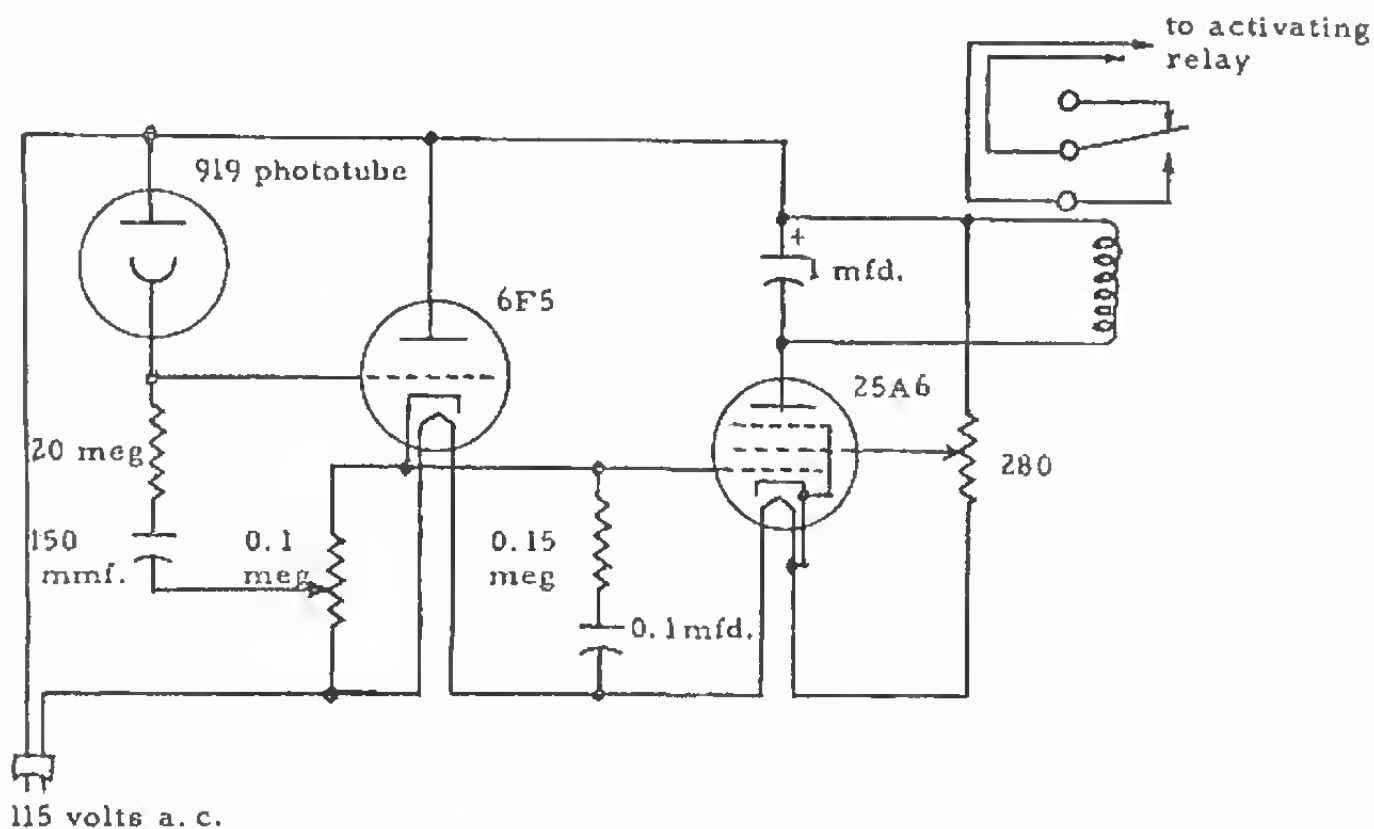

Figure 40.

triggered, and the relay operates.

This kind of photoelectric relay is quite sensitive, and will perform with a light pulse as brief as 1/60th of a second in duration. Placement at a crime site must be accomplished with discretion, since the light of a passing vehicle might cause initiation at the wrong time.

The *photovoltaic* devices are the most modern. They are semi-conductor or, in other words, "solid-state" components, and they incorporate the principle of the conversion of radiant energy directly into usable electrical power. The photovoltaic phenomenon is founded upon the basic photoelectric equation of Albert Einstein, namely:

$$\frac{mv^2}{2} = hf - W$$

which states that the electrical energy of the photoelectrically excited electron is proportional (by Planck's constant h) to the frequency of the impinging radiant energy. W is

front view   side view

Figure 41.
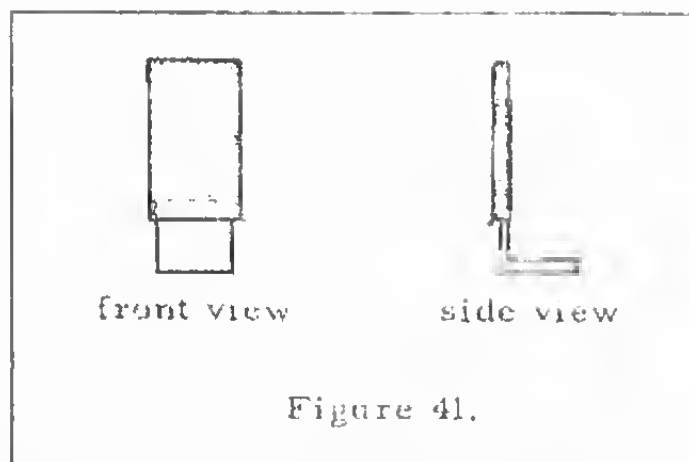
the work function or the energy necessary to free the electron from its bonds in the atom. Being solid-state, these units have no glass envelope and hence, no vacuum. They are rugged in the extreme, and will continue to operate in temperatures ranging from minus 195 degrees to plus 100 degrees Centigrade. They are also very tiny. Figure 41 depicts a typical photovoltaic cell in its actual size.

This amazingly small physical size, together with husky and simple construction, makes these components absolutely ideal as a trigger

international
B2M
sun batteries

1,000
ohms
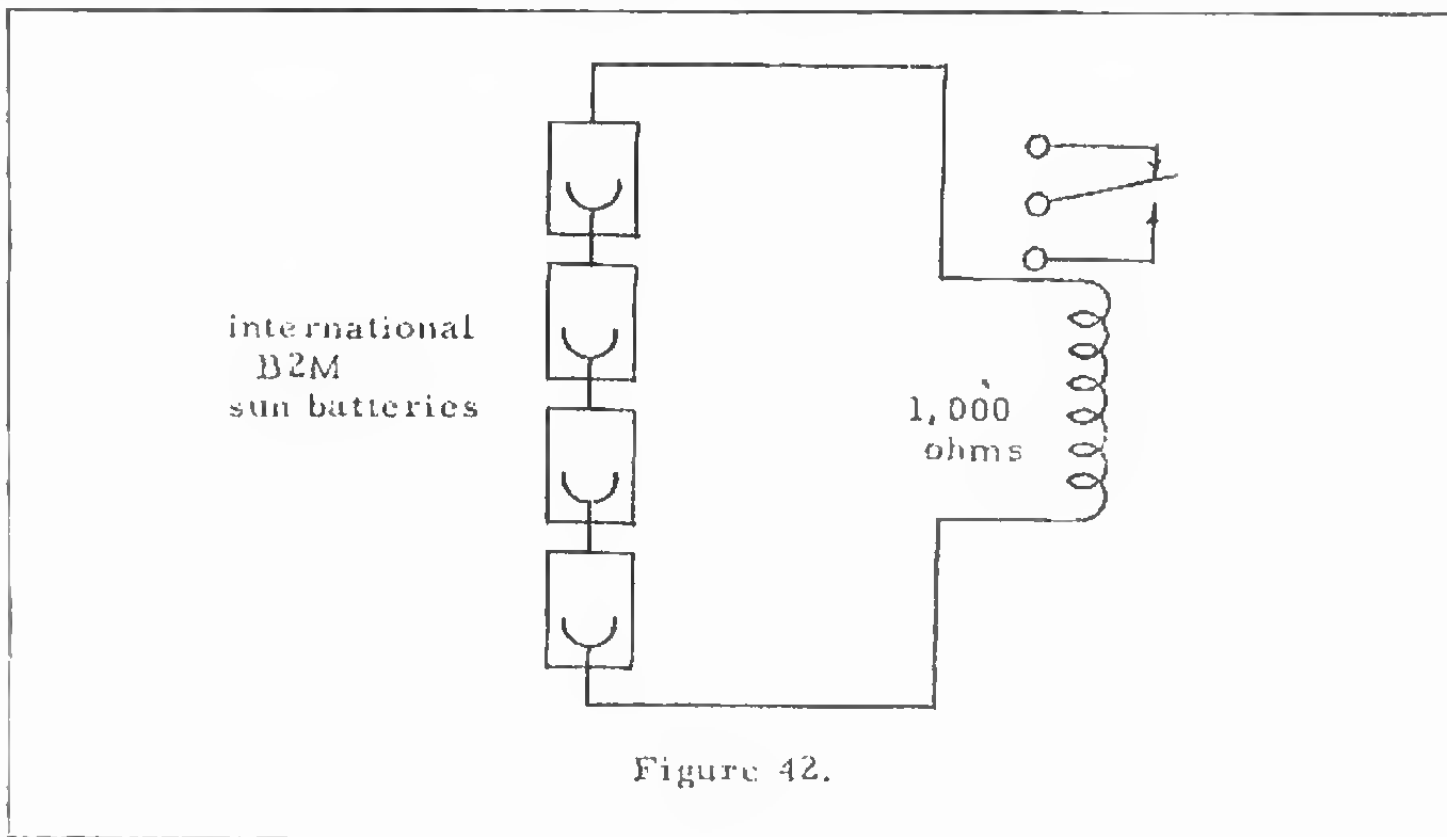
Figure 42.

tor electronic arson. They do not even need an external source of electricity. The straightforward configuration of an operating circuit using this device is shown in figure 42.

From an electrical viewpoint, nothing could be less complicated. Light falls upon the surface of the photovoltaic cells, a current of electricity is generated by them, and the relay operates because of the current passing through its actuating coil. Little imagination is required to see that this kind of a circuit could trigger a fire or an explosion and remain relatively unobserved after the fire. This circuit will fulfill its particular service with large excursions in light level, but it is not too sensitive.

This problem of sensitivity is easily overcome by using a similar cell as a *photoconductive* device. How this is done is shown in figure 43.

If a small voltage is instituted across a series of these photocells, little current will flow through them until they are exposed to light. When light does impinge upon their surface, they begin to operate exactly like a "light-operated-valve"; the greater the amount of light falling on the cell, the greater the current that flows through the cell. The maximum current, or course is subject to the physical and constructional limitations of the individual cell. This type of application increases the apparent sensitivity from one and one-half to ten times, this particular device operating at a light level of about 50 foot-candles.

Figure 44 illustrates a method of combining the solid-state photoconductive cell with a thyratron tube in order to achieve an even greater sensitivity.
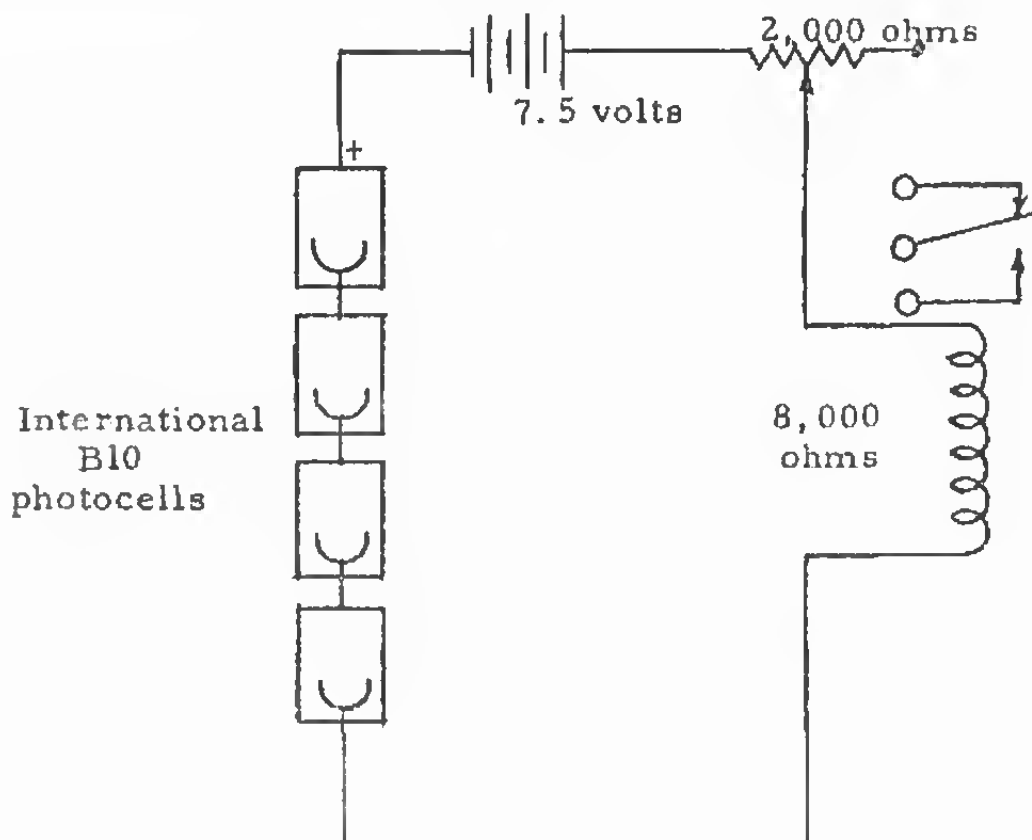

Figure 43

The type 6012 xenon-filled thyratron is normally in a non-conducting state. When light falls on the photoconductive cells, the control grid of the tube begins to go more and more positive as the current through the cells increases. Finally, a state of conduction is acquired within the thyratron, and the relay operates. This circuit falls into the grouping known as ultra-sensitive because of the fact that it will perform with the presence of one-half of one foot-candle of light.

Any of these circuits will function through variations in the ambient light level in a structure or through variations in the intensity of a sharply defined and restricted artificial light source. They may be readily implemented into a trigger mechanism by the expedient of placing them in an exposed position on the exterior of the building being prepared. If the device to be activated were connected to the bottom set of relay contacts, the rising of the sun and the consequent rise of the outside illumination to a certain critical level would accomplish the desired result through the closing of the relay. If the device to be activated were connected to the top pair of relay contacts, a different sequence would be followed. The relay must, in this case, first be energized by exposing the sun batteries to high illumination. While the relay remains closed, final connections are made. When the sun sets, the outside illumination begins to fall. When it declines to the necessary intensity, the relay opens and the "plant" is set off.

The photocell might be adjusted to trigger the relay when a street light is turned on; it could be hidden behind a small hole in an opaque surface so that it would trigger at a

6012
Xenon
filled
thy-
ratron
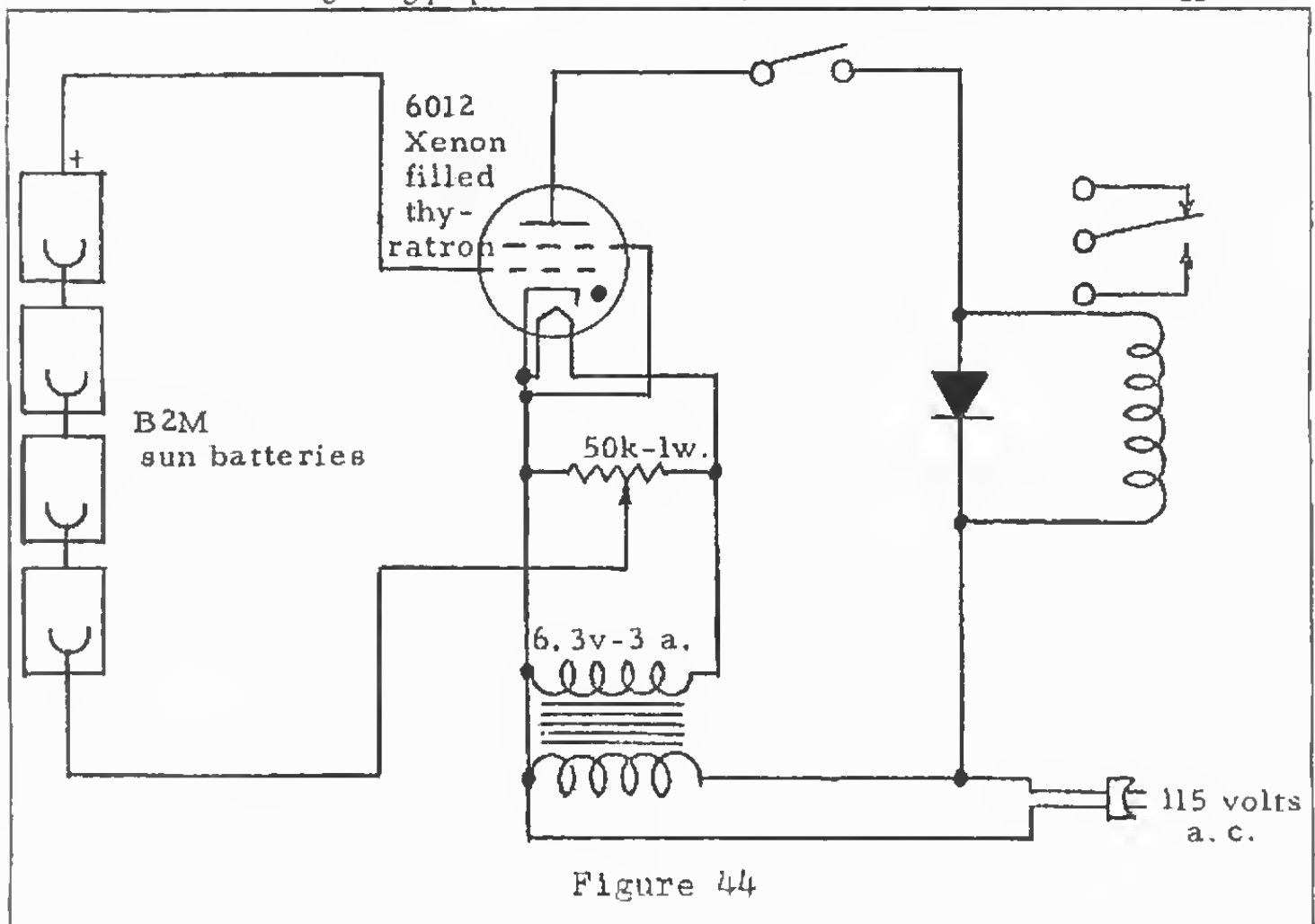
B2M
sun batteries

50k-1w.

6.3v-3 a.

115 volts
a.c.

Figure 44

definite position of the sun; a pilot light on an instrument panel or on a telephone switchboard could operate it. The applications are absolutely innumerable.

Look for these devices if the cause of the origination of a fire or an explosion is undetermined, and if the event occurs at sunrise or at sunset. If a light source other than the sun is utilized, any other correlating time-factors will be most dubious and obscure. If solid-state components are used, little will be found in the ashes except possibly the small metal bracket on which they are formed. If vacuum tubes are used, the usual remains associated with an electronic chassis may be anticipated.

IX. SOUND OPERATED DEVICES:

One of the basic tenets of the science of physics has to do with the transducer. Evolving from the Latin word *transducere*, meaning literally "to lead across," it comprehends devices actuated by power from one system

and supplying power to another system. If this sounds somewhat esoteric and abstract, consider the fact that the familiar microphone and the common loudspeaker are both members of this species.

The specialized function of this kind of transducer is most vital. Electronic circuits cannot amplify or otherwise process sound energy per se; in the jargon of the technician, "piping sound into a room" does not mean sending it through a water pipe. Sound energy must first be transformed into a corresponding pattern of electrical energy that *can* be processed by electronic means and then, as in the art of broadcasting, must be reconverted back into sound energy encompassed in a band of frequencies that can be perceived by the human sense organs.

The transmission of sound through the air actually consists of an alternate compression and rarifaction of the molecular structure of the air itself. When this wave-like movement
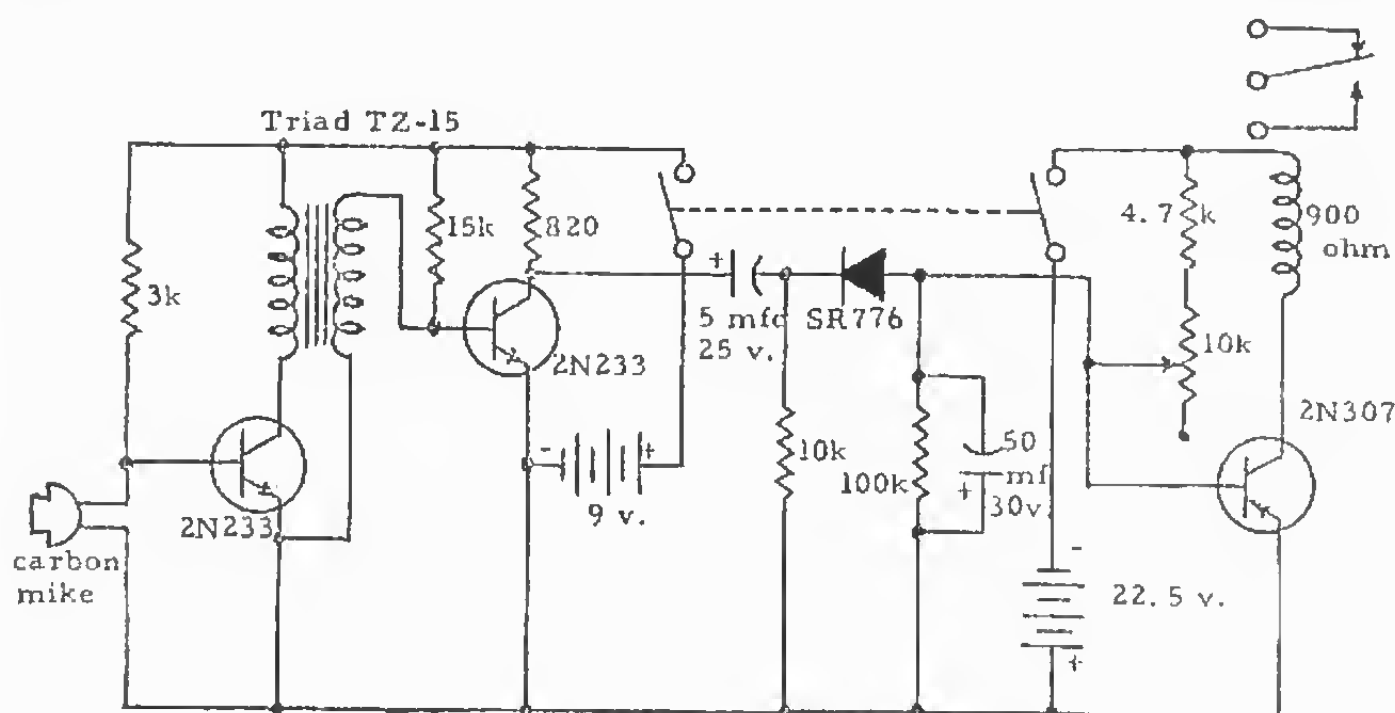

Figure 45.

intrudes upon the tympanic membrane of the human ear, or upon the flexible diaphragm of a microphone, mechanical movement is exchanged with that medium.

In one much-used type of microphone, a small movable coil of wire is attached to the diaphragm, and the coil placed in close juxtaposition to a permanent magnet. When sound waves agitate the diaphragm, it moves; the coil, being linked to it, also moves and in so doing, cuts lines of force emanating from the magnet. The end product is a feeble current of newly generated electricity whose intrinsic pattern is characteristic of the particular sound involved. This minute current, generated by and now bearing the image of its progenitor, may be then passed along to an electronic amplifier or to some other similar device.

Once the sound energy has been converted to electrical impulses, it is not mandatory that the reverse process be carried out. In figure 45, the net result is the mechanical movement of a relay.

Transistors have been used in this hookup, so that the power requirements would be minimal, and so that the size of the completed unit could be sharply reduced. A carbon microphone is used as a transducer. Here, the movement of the instrument's diaphragm alternately compresses and releases pressure on carbon granules within the body of the microphone. This has the effect of regulating the flow of direct current through the microphone. The ensuing electrical pattern, now referred to as the modulated direct current, is amplified by the first transistorized stage, and coupled to the second stage of amplification through the transformer. The output of the second stage is rectified by the diode, and the rectified current is used to control the third transistor. When a loud enough sound level reaches the microphone, a critical operating point is realized in the third stage, the transistor conducts, and the relay closes. The 10,000 ohm variable resistor makes it possible to pre-select the sound level at which the relay will move.

Incorporation of this kind of a unit into an arson or into a criminal explosion creates a new set of problems for the law enforcement agencies. Such a device may be wired to a "plant," and the microphone placed near a telephone. If this is done at the beginning of a weekend or during the first day of a holiday period, the prepared building would remain uninhabited long enough for the criminal to travel to a great distance before making the long-distance telephone call that would initiate the actual crime. This unit would function just as well in the vicinity of a railroad, an airport, or in any situation where the existence of a high noise level could be predicted.

Another similar appearing device will carry out the long distance 'phone call gambit but with a slightly different twist. If two electrical conductors are laid side by side, and if a current of electricity is passed through one of the conductors, a sympathetic or *induced* current is found to flow through the second or unconnected wire. In figure 46, induction is the source of our ultimate control impulse.

An inductive device, popularly known as a telephone pickup coil, and originally designed for the recording of telephone conversation, is wired to the first stage of amplification in an electronic hookup whose action is almost the same as that of the circuit shown in figure 45. The pickup coil is placed under any convenient telephone. When the impulse necessary to ring the bell flows through the instrument, a current is induced in the pickup coil. This resulting signal, after further processing, culminates in the closing of the relay.

As modern communications technology advances, it will become more difficult to detect

this kind of trigger mechanism. In some instances, if a voice-operated or inductive device is suspected, inquiries can be conducted to determine whether or not a long distance call was made to the telephone number in question at the time when the crime was alleged to have taken place. With the increase in the use of automatic equipment, the advent of direct distance dialing from one city to another, this procedure will not always prove to be fruitful.

Such units will usually be found in close proximity to a telephone, but in some applications of the sound operated relay, this may not be true. The circuitry is miniaturized for the most part, and the remains will be difficult to spot after a disaster. Aside from the conventional electronic debris that might be expected, look for a metal shell of a microphone, or for the inductive loop that may have been protected from destruction by being hidden under the telephone.

X. TEMPERATURE AND MOISTURE OPERATED DEVICES:

Temperature excursions and even seeming-

ly innocuous variations in the moisture content of the atmosphere can trigger an arson or an explosion with devastating efficiency. Admittedly, this comprises a somewhat subtle approach to the problem but, of course, to the criminal mind, obscurity of intent and cyrptogrammaric methods are highly desirable.

One of the most common means employed to sense changes in temperature is not electronic at all, but rather electro-mechanical. It is a well known physical manifestation that most solids expand with the application of heat, and contract with the application of cold. This medium is predicated upon the fact that different solids do this expanding and contracting at disparate rates. This may be expressed as a coefficient of linear expansion per degree of temperature change. Three of the most used metals exhibit the following expansion coefficients per degree Fahrenheit:

aluminum	.000014
brass	.000011
copper	.000009

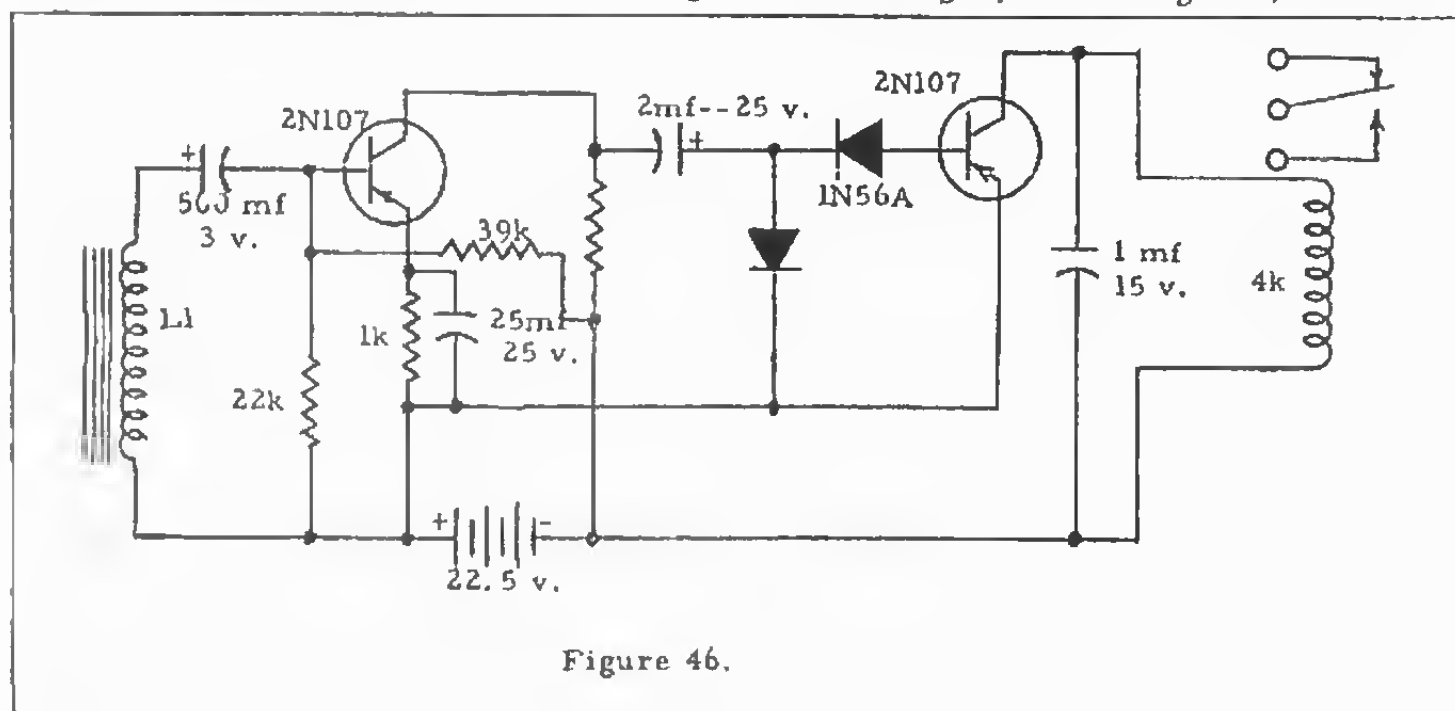Should strips of two of these dissimilar metals be tightly riveted together, and should

Figure 46.

heat or cold be applied to the resulting "sand-wich," either expansion or contraction will follow. Since the metals do not possess the same expansion coefficients, stresses will be set up and deflection will be the end product. This effect can be utilized as a trigger device with little difficulty. This conformation makes up the everyday thermostat that is to be found in many electrical devices within the home and business establishment. A quick perusal of figure 47 will show how the temperature-induced bending of the bi-metallic element completes a circuit which operates the activating relay.

The same thing can be done with a circuit that embodies pure electronics. All transistors are characterized by a certain amount of leakage current which varies directly, within some fixed temperature limits, with the heat applied. In figure 48, the transistor's accompanying wiring is arranged so that little current flows through the relay coil. When enough heat is applied, however, the current flow through the transistor increases by a propor-

tional amount and finally, the relay closes. By adjusting the circuit so that the relay remains in a closed position at a given heat level, and by using the top pair of relay contacts, the device can be made to trigger a "plant" with a decrease in temperature.

Installation of these units will be very unobtrusive. Look for them near a furnace or a heating duct in a home, or adjacent to a furnace or an oven in an industrial plant.

Various hygrometric or moisture-sensing units are on the present day market. Many of them are of comparable size and shape to the one depicted in figure 49, although their uses are widely divergent. When used as the controlling component in an electronic circuit, they can automatically raise the top of a convertible or close a car window if rain threatens. They can notify parents when a child is incontinent during sleep (under the hideousiy "cute" trade name of "wee-alarm"). They can telemeter the moisture content of the upper atmosphere to people on the ground. They can trigger an arson.

Figure 47.
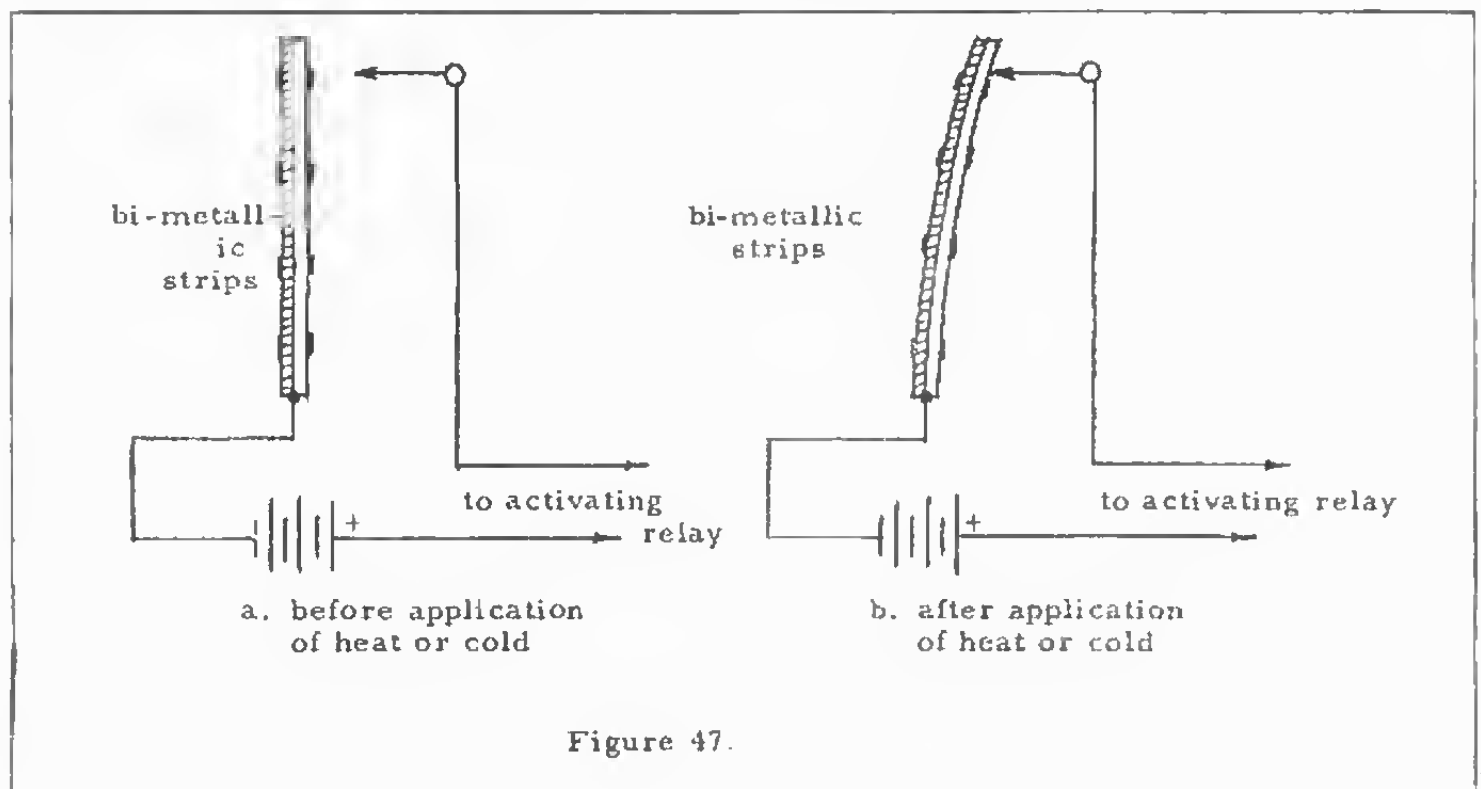
If a ready explanation of a crime does not present itself, consider the existence of one of these little gems, especially if the incident occurs during a period of high humidity or at the beginning of a rain.

XI. IGNITION OR DETONATION BY RADIO

In describing the varied electronic circuitry in the preceding pages of this treatise, operation has been explained as a function of the movement of electricity through wires. Not touched upon is the somewhat surprising concept of electrical currents that cannot be confined to a wire, and this idea is the basis for the piece de resistance of electronic arson; namely, the activation of a device by remote control, from a distance, and without the use of connecting wires.

It has become a conventional practice to speak of the electricity used within the home as coming from a 110 volt service or from a 220 volt service. The assignation of a definite

value to this voltage seems to imply that its magnitude is constant. However, these maximum potentials are realized for only a small percentage of the total time, the actual value constantly rising and falling, due to the fact that the current is of an alternating nature. Figure 50 illustrates this fundamental relationship. Practically all of the electricity in the homes in the United States is supplied at a frequency of 60 cycles per second. At the start of a cycle (the left hand extreme on the zero axis) in figure 50, the voltage is at zero and rises rapidly with time to its maximum potential on the positive side of the zero axis.

At this point, its value declines swiftly to zero again, and the potential begins a quick rise to maximum on the negative side of the zero axis. The fall of the potential to the zero axis once again completes one cycle. In the case of 60 cycle current, this takes place in 1/60th of a second.

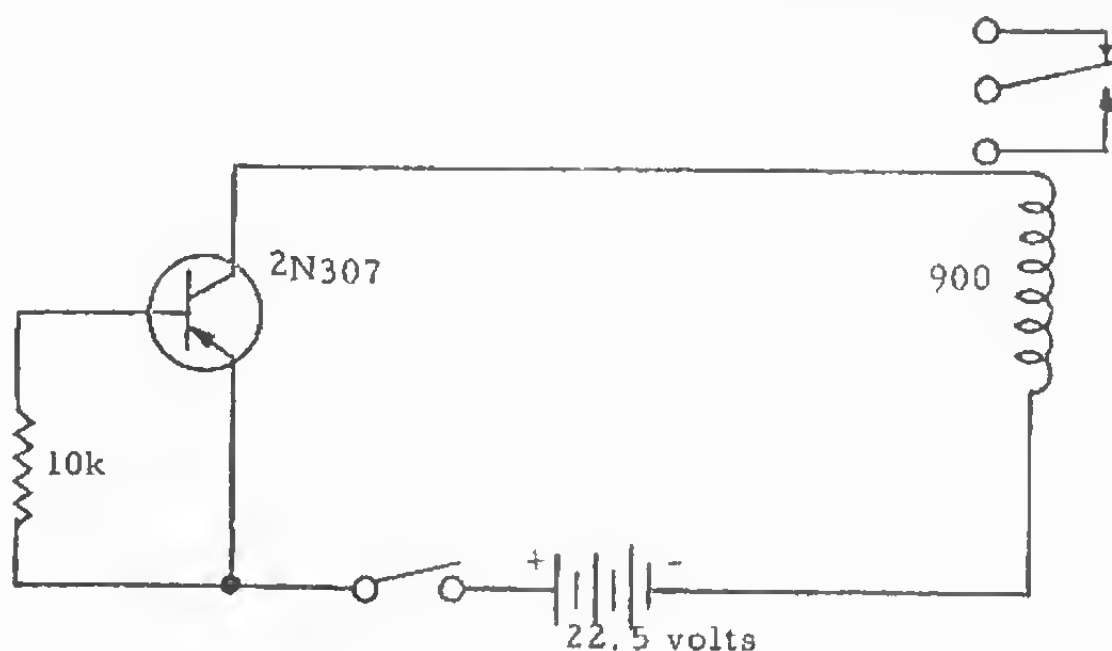If this electrical current is passed through a wire, it can be shown that the wire is sur-

Figure 48.

Figure 49.

rounded by an electromagnetic field set up by the current. Furthermore, the field is alternately expanding and collapsing at a speed corresponding to the frequency of the alternating current. (Fig. 51)

This is quite an ordinary physical phenomenon that forms the foundation for many electrical and electronic devices; a phenomenon that takes on an added and vital significance if one change is made.

It can be demonstrated in the laboratory that the expansion and the collapse of such an electromagnetic field requires a finite amount of time. If the frequency is raised to a certain rate so that the collapse of one field cannot be completed before the expansion of another cycle's field begins, the electrical energy cannot be confined to the conductor and will push out all directions much like the ripples in a pond resulting from a thrown rock. This is termed *radio-frequency energy*, and makes practical all broadcasting as we know it.

The generation, transmission and reception of radio frequency, or RF, energy can give rise to all sorts of complicated computations and special considerations of physical laws and principles, but on the surface, the general procedure looks very easy. (Fig. 52) RF energy is generated in a transmitter of some type and is coupled to an antenna. The resultant waves spread out from the antenna and eventually arrive at a receiving antenna. This is attached to a receiver whose circuitry is sensitive or resonant to the particular fre-
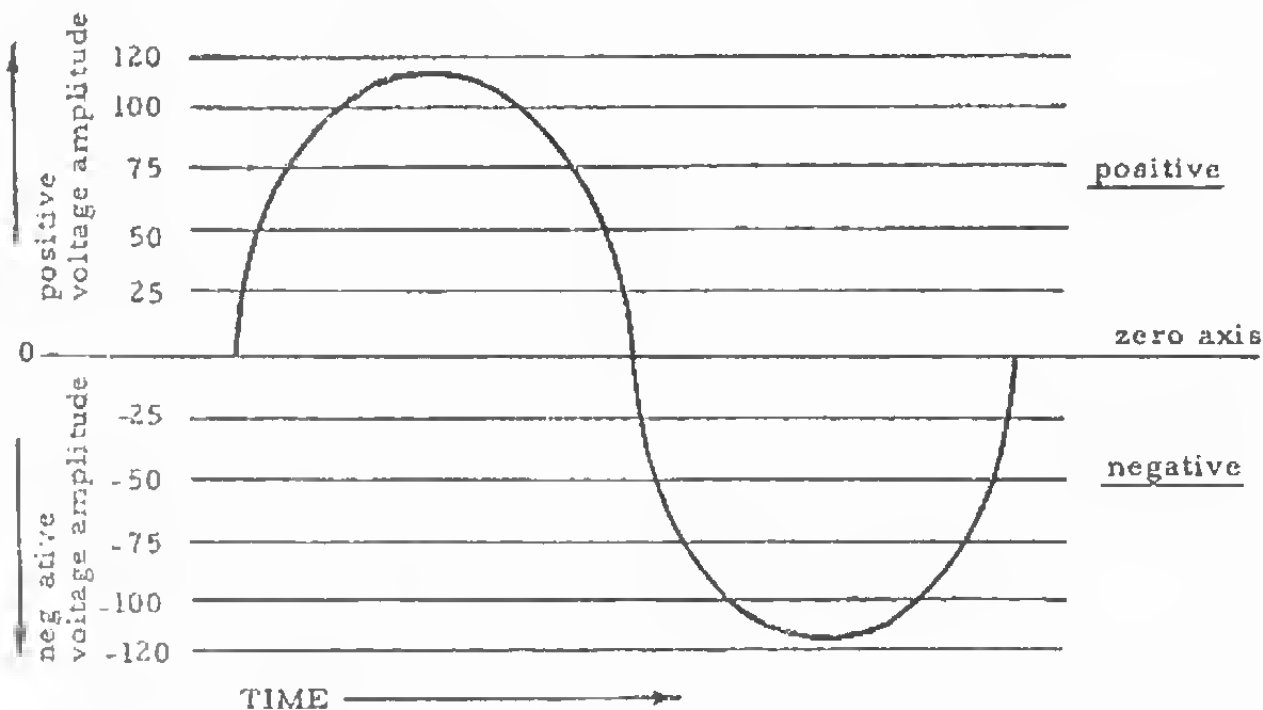

Figure 50.

quency being transmitted. Further wiring within the receiver converts this energy to audible sound or, as desired in a trigger mechanism, into the movement of a relay.

Before radio-controlled apparatus can be employed, several important questions must be answered:

1. From what distance is the device to be triggered?
2. How powerful must the transmitter be?
3. What kinds of transmitting and receiving antennae are necessary?
4. What kind of receiver must be utilized?

Unfortunately, there are no hard and fast answers to these questions; answers that will give one hundred percent reliability at all times. This makes the use of radio control just a little ticklish under certain conditions. For example, the tiny transmitter shown in figure 53 was originally designed to open a garage door at close range.
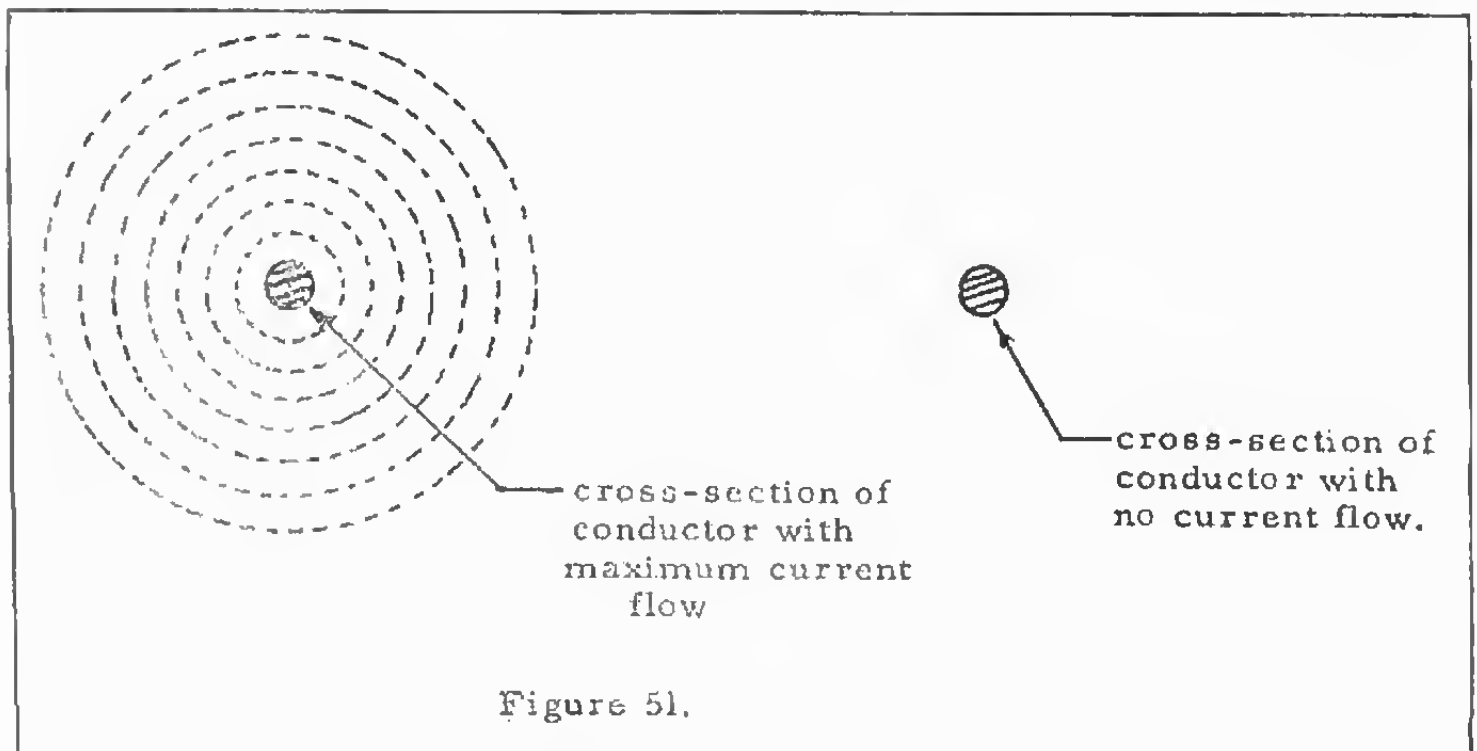
It was intended to be used with the relatively insensitive receiver in figure 54.

When attached to a short antenna, it will do its job admirably, and will not be accidentally operated by some other radio transmitter, primarily because of the insensitivity of the receiver and because it is not capable of perceiving signals except on a fixed frequency. On the other hand, if the output of this small transmitter is fed into a larger antenna or an antenna with directive characteristics, and if the receiver is made more sensitive, longer range operation is possible. Any "ham" will confirm the fact that under certain conditions, a few watts of RF power can be heard, literally, around the world.

The necessity for low receiver sensitivity to guard against accidental operation by an unwanted signal can be obviated by superimposing intelligence on the primary RF energy (modulation), by coding this intelligence, and by providing the receiver with circuits responsive only to this exact code. Receiver sensitivity can be increased to an amazing point where the most infintessimal signal can be picked up and used.

Commercial garage door openers are readily obtainable and can be modified to give the de-

cross-section of conductor with maximum current flow

cross-section of conductor with no current flow.

Figure 51.

sired results without too much trouble. There are also many devices for sale that were built for the purpose of radio controlling model ships and airplanes. These units usually have a somewhat longer normal range of operation, and many of them are coded in some way to permit control of a number of individual circuits through one transmitter.

Range of performance can be increased by raising the power of the transmitter. Amateur transmitters in powers up to 1,000 watts can be bought from a number of retail and wholesale outlets. A skilled electronics technician can build a comparable instrument without any great effort.

In short, the use of radio control will necessitate some knowledge, care and experimentation, but the results will probably be worth the trouble to an advanced arsonist. This method is not for beginners.

It is doubtful that a transmitter used in this context can ever be discovered except through the voluntary surrender by the user. The unit could be located anywhere, and because only a brief pulse would be needed to initiate the crime, standard direction finding techniques would be useless. The size and the use of all transmitting apparatus is closely regulated by federal law, but these limitations would not disturb the criminal. Of course, should he be convicted of arson, and should it be proved that he initiated the crime by the use of an illegal radio transmitter, an additional federal charge can be instituted against him.

It is very possible that remains of the receiver could be discovered in the fire residue. The antenna might be in evidence. Remember that the innocent appearing television antenna could be used as a highly directional and efficient antenna for this kind of reception.

XII. SUMMATION:

Here, then, is an exposition of some of the ways in which electronics can be subverted to criminal purposes. There will be those readers who agree that this new field comprises a present and a growing threat that must be faced and dealt with by law enforcement agencies. There will be those who laugh in derision and hurl the handy slur of "Rube Goldberg devices." But bear in mind that although most of the hookups proposed by the beloved Rube fulfilled their functions in a jesting way,
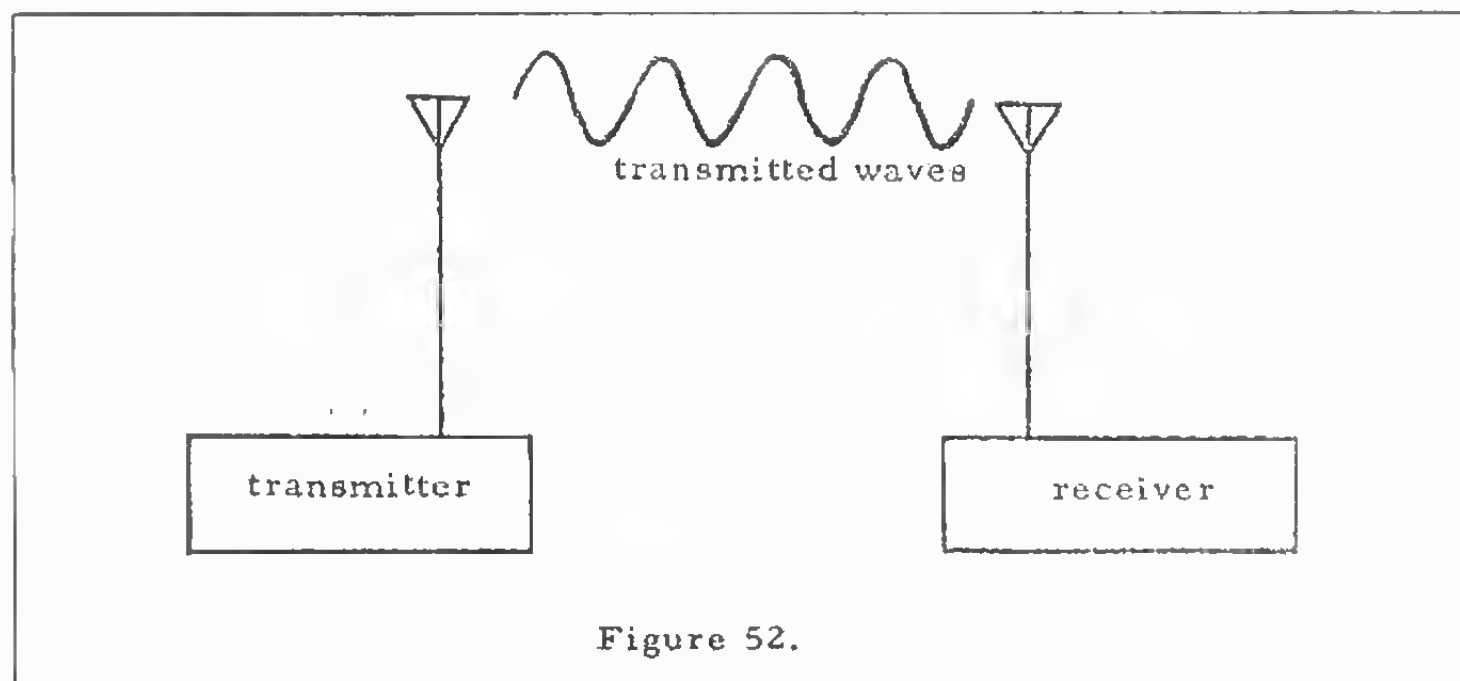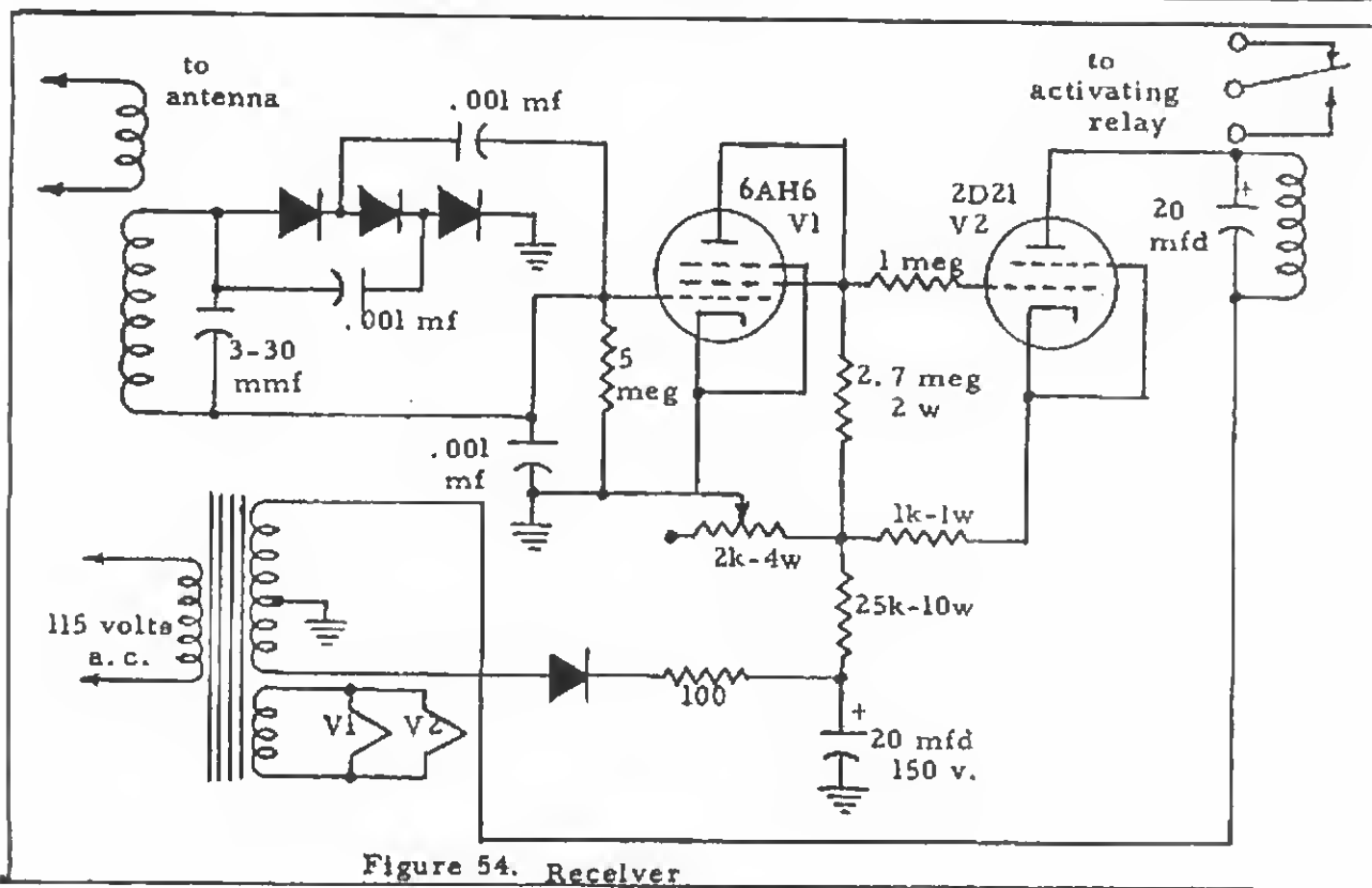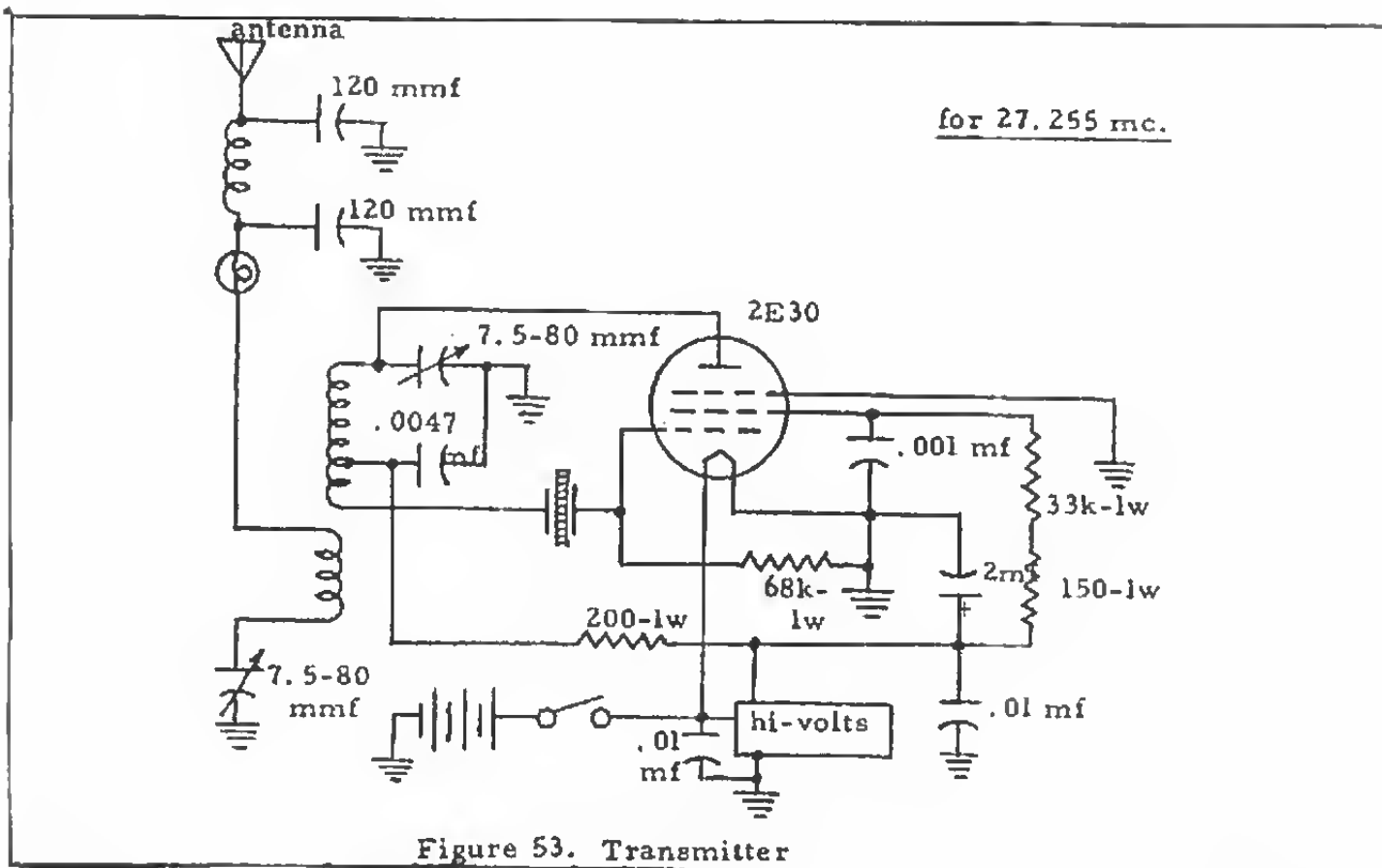

Figure 52.

antenna

120 mmf

120 mmf

for 27.255 mc.

2E30

7.5-80 mmf

.0047
mf

.001 mf

33k-1w

68k-
1w

2m

150-1w

7.5-80
mmf

200-1w

hi-volts

.01
mf

.01 mf

Figure 53.   Transmitter

to
antenna

.001 mf

to
activating
relay

.001 mf

6AH6
V1

2D21
V2

20
mfd

3-30
mmf

.001 mf

1 meg

.5
meg

2.7 meg
2 w

.001
mf

115 volts
a.c.

1k-1w

2k-4w

25k-10w

V1   V2

100

20 mfd
150 v.

Figure 54.   Receiver

they were highly impractical. Electronics, conversely, is the essence of practicality.

The science of electronics is of recent origin; it is an area of the most intense specialization; in some applications, and to the uninitiated, it even smacks of the occult arts. Therefore, it is to be assumed that many juries and judges will be extremely reluctant to deprive a litigant of freedom or perhaps of life without the presentation of clear and irrefutable proof that electronics was at the root of the crime.

The investigator will have to be meticulous in his observations and in his preservation of physical evidence. Preliminary reports, though sketchy, have already pointed to the fact that if tests of confiscated electronic gear are necessary, they must be conducted at the scene and under exactly the same conditions in which they were originally intended to be used. If this procedure is not followed, their probable value as evidence will be nullified.

If this sounds like the beginning of an uphill struggle, the implied impression is correct. The dream of the arsonist is to commit a crime that will appear as though it occurred from natural circumstances. The investigator must first prove the existence of the corpus delicti. If electronics is involved, he must ferret out the details as to how it was used, and must then convince people, often hostile and uninformed, of these facts. Hostility may, with certainty, be expected, since humanity tends to distrust that which it does not understand.

On the other side of the coin, the officer must guard against an overzealous attitude in seeking to prove the use of electronics in a criminal situation. All electronics engineers, mathematicians and technicians who sustain a loss are not necessarily incipient criminals. They may deal in commodities that are, in the vernacular, "way-out," but they may not have used these abilities for the wrong purposes. Radio "hams" and experimenters, for example, might possess a welter of electronic equipment, but would have every right to possess it and to work with it in a normal way.

In this final analysis, it is the purpose of this article to show some of the things that can be done with electronics; to set forth the proposition that they probably *are* being done and *will continue to* be done; and to encourage the investigator to study enough of this art so that it might be able to furnish the key in explaining some enigmatic circumstance.